NASA-TM-84203

# AgRISTARS

E82-10219

SR-J1-04195
JSC-17792

A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing



## Supporting Research

November 3, 1981

**SEMI-ANNUAL PROJECT MANAGEMENT REPORT**

**PROGRAM REVIEW PRESENTATION TO LEVEL 1, INTERAGENCY COORDINATION COMMITTEE**

(E82-10219) AGRISTARS. PROJECT MANAGEMENT REPORT: PROGRAM REVIEW PRESENTATION TO LEVEL 1, INTERAGENCY COORDINATION COMMITTEE (NASA) 105 p HC A06/MF A01 CSCL 02C

N82-23592

Unclas
G3/43 00219

Lyndon B. Johnson Space Center
Houston, Texas 77058

THIS IS THE SEMI-ANNUAL REPORT OF SUPPORTING RESEARCH (SR) STATUS TO AgRISTARS PROGRAM AND SR PROJECT MANAGEMENT. IT REPRESENTS STATUS FROM 1 MAY 1981 THROUGH 31 OCTOBER 1981 THIS REPORT ALSO IS THE BASIS OF THE SR PROJECT PRESENTATION TO THE AgRISTARS LEVEL 1, INTERAGENCY COORDINATION COMMITTEE ON 3 NOVEMBER 1981.

R B McDonald

R. B. McDonald
SR Project Manager

# LEVEL I BRIEFING
NOVEMBER 3, 1981
SUPPORTING RESEARCH OUTLINE



| | | |
|---|---|---|
| OVERVIEW | R. MACDONALD | 1:30 - 1:45 PM |
| O RESEARCH AND DATA SYSTEMS SUPPORT FUNDING HISTORY | | |
| O FY80 OBJECTIVES/ACTIVITIES | | |
| O FY80 ACCOMPLISHMENT HIGHLIGHTS | | |
| O RESEARCH AND DATA SYSTEMS SUPPORT FUNDING - FY81 | | |
| + PRE-APRIL | | |
| + POST-APRIL | | |
| + CURRENT | | |
| O FY81 OBJECTIVES | | |
| O GENERAL APPROACH/ORGANIZATION | | |
| RESEARCH PROGRAM REVIEW | | |
| O INTRODUCTION | F. HALL | 1:45 - 2:00 PM |
| + SYNOPSIS OF MAY LEVEL I BRIEFING | | |
| + SIGNIFICANT ACTIVITY AREAS SINCE MAY | | |
| O ACCOMPLISHMENTS/STATUS/ISSUES | D. PITTS/R. HEYDORN | |
| + SCENE RADIATION | D. PITTS | 2:00 - 2:45 PM |
| + PATTERN RECOGNITION | R. HEYDORN | 2:45 - 3:30 PM |

LEVEL I BRIEFING
NOVEMBER 3, 1981
SUPPORTING RESEARCH OVERVIEW

| | | FY80 OBJECTIVES | | |
|---|---|---|---|---|
| DATA SYSTEMS | 3650K | O FLEXLAB II DATA SYS. SUPPORT<br>O LANDSAT DATA INTERFACE<br>O DESIGN/PURCHASE S.O.W. DIGITAL DATA ANALYSIS SYSTEM | O PDP 11 OPERATION<br>O GROUND TRUTH DATA PROVISIONING | |
| RESEARCH | 3324K | AREA ESTIMATION | CROP STAGE OF DEV. | CROP COND. |
| | 6974K | O MACHINE PROCESSING PROCEDURE EFFICIENCY INCREASE<br>O AUTOMATION OF LABELING<br>O EVALUATE CORN/SOY PROCEDURES | O EVALUATE EXISTING AGROMET CORN/SOY MODELS<br>O IMPROVE WHEAT MODELS<br>O DEVELOP PLANTING DATE MODELS<br>O USE OF SPECTRAL DATA<br>O BARLEY MODEL | O INITIATE STUDIES OF SPECTRAL INPUTS |

O CONDUCT PROGRAM PLANNING AND SOLICITATION TO SCALE RESEARCH UP TO PLANNED FY81 LEVELS

LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW

RESEARCH OBJECTIVES - FY80

- INCREASE THE EFFICIENCY OF MACHINE PROCESSING PROCEDURES.
- INCREASE THE DEGREE OF AUTOMATION POSSIBLE FOR LABELING PROCEDURES.
- INVESTIGATE FEATURES/APPROACHES TO IMPROVE CROP SEPARABILITY FOR SMALL GRAINS, CORN AND SOYBEANS.
- EVALUATE AT HARVEST CORN/SOYBEAN PROCEDURES DEVELOPED DURING LACIE TRANSITION YEARS.
- EVALUATE EXISTING AGROMET CROP STAGE OF DEVELOPMENT MODELS FOR CORN AND SOYBEANS.
- IMPROVE CROP STAGE OF DEVELOPMENT MODELS FOR WHEAT.
- DEVELOP PLANTING DATE MODELS TO START CROP STAGE MODELS.
- INVESTIGATE THE USE OF SPECTRAL DATA IN CROP STAGE ESTIMATION.
- DEVELOP BARLEY CROP STAGE MODEL.
- INITIATE STUDIES OF SPECTRAL INPUTS TO CROP CONDITION.
- CONDUCT PROGRAM PLANNING AND SOLICITATION TO SCALE RESEARCH PROGRAM UP TO PLANNED FY81 LEVELS.
- CONTINUE RESEARCH ON DESIGN OF LOW COST MULTI-USE RESEARCH FIELD RADIOMETER.
- INITIATE RESEARCH ON AUTOMATED MSS REGISTRATION APPROACHES.

LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW

FY80 ACCOMPLISHMENTS HIGHLIGHTS

1. DEVELOPED AND DELIVERED IMPROVED SMALL GRAINS, CORN/SOY AREA ESTIMATION PROCEDURES
    - O EFFICIENCY IMPROVED
    - O AT HARVEST PROCEDURES

2. DEVELOPED TEMPORAL PROFILE TECHNIQUE
    - O INCREASED AGRONOMIC UNDERSTANDING OF MULTIDATE DATA
    - O WHEAT/BARLEY SEPARABILITY INVESTIGATED

3. CROP STAGE MODELS DEVELOPED AND EVALUATED
    - O EVALUATED EXISTING CORN/SOY AGROMET
    - O DEVELOPED CORN/SOY SPECTRAL MODEL
    - O IMPROVED WHEAT MODEL TO ACCOUNT FOR MOISTURE
    - O DEVELOPED PLANTING DATE MODEL FOR SMALL GRAINS
    - O EVALUATED EXISTING BARLEY MODEL

4. SPECTRAL INPUTS TO CROP CONDITION STUDIED.

LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW

FY81 OBJECTIVES

- O DELIVER AN EFFICIENT AND ACCURATE CORN/SOY AT HARVEST AREA ESTIMATION TECHNIQUE BASED ON PROFILE TECHNOLOGY
- O DELIVER SMALL GRAINS MACHINE PROCESSING PROCEDURE WITH INCREASED EFFICIENCY.
- O INITIATE DEVELOPMENT OF EARLY SEASON AND MULTISEGMENT CROP ID AND AREA ESTIMATION PROCEDURES.
- O INVESTIGATE MACHINE PROCESSING PROCEDURES WHICH REDUCE ESTIMATION BIAS RESULTING FROM SPECTRAL CONFUSION.
- O INCORPORATE PROFILE TECHNIQUES INTO LABELING PROCEDURES.
- O EVALUATE PLANTING DATE AND CROP STAGE OF DEVELOPMENT MODELS ON INDEPENDENT YEAR.
- O IMPROVE AND EVALUATE BARLEY STAGE OF DEVELOPMENT MODELS.
- O DEVELOP AND EVALUATE TECHNIQUES TO ESTIMATE SRI AND LAI AS INPUTS TO YIELD.
- O DEVELOP AFFORDABLE, PORTABLE PRECISION FIELD RADIOMETER TO SUPPORT TM STUDIES.
- O INITIATE GROUND DATA COLLECTION IN ARGENTINA.
- O DEVELOP AND EVALUATE IMPROVED REGISTRATION CAPABILITY.
- O DEVELOP FOLLOW-ON RESEARCH PLAN IN SUPPORT OF FY82 AND FY83.

FY80 ACCOMPLISHMENTS HIGHLIGHTS

1. DEVELOPED AND DELIVERED IMPROVED SMALL GRAINS AREA ESTIMATION PROCEDURE -- NONSUPERVISED, CLUSTER BASED APPROACH PROVIDED SIGNIFICANT EFFICIENCY INCREASE -- FEWER SAMPLES TO LABEL.

   EXTENDED SMALL GRAINS PROCEDURES TO CORN/SOYBEANS AT HARVEST AND OBTAINED ACCURACIES EQUIVALENT TO SMALL GRAINS IN INDIANA, ILLINOIS, AND IOWA WHERE CORN/SOYBEANS ARE PREDOMINATE CROPS.

2. MODELS DESCRIBING THE TEMPORAL BEHAVIOR OF GREENNESS PERMITTED SPECTRAL DATA TO BE UNDERSTOOD IN TERMS OF AGROPHYSICAL CHARACTERISTICS OF CROP CANOPIES.

   THE SEPARABILITY OF WHEAT AND BARLEY WAS INVESTIGATED USING PROFILE MODELS. IN SOME SEGMENTS THESE CROPS WERE VERY SEPARABLE -- IN OTHERS ONLY MODEST SEPARABILITY WAS OBSERVED -- FURTHER STUDIES WERE DEFINED TO UNDERSTAND WHICH CROP CHARACTERISTICS GIVE RISE TO SEPARABILITY.

3. CORN/SOYBEAN STAGE OF DEVELOPMENT MODELS WERE EXTRACTED FROM THE LITERATURE AND EVALUATED AT STATE AND CRD LEVELS -- MODELS WORKED REASONABLY WELL AT THESE LEVELS WHEN STARTED WITH GROUND TRUTH PLANTING DATE. IMPROVEMENTS WERE BELIEVED POSSIBLE BY ADDING MOISTURE DEPENDENCE.

   INVESTIGATIONS OF PROFILE MODELS SHOWED A STRONG RELATIONSHIP BETWEEN CROP STAGE OF DEVELOPMENT AT A SPECIFIC CALENDAR TIME AND THE FRACTIONAL AREA UNDER THE GREENNESS PROFILE AT THAT TIME -- PROVIDED A RETROSPECTIVE BUT ACCURATE ESTIMATE OF GROWTH STAGE AT ANY DATE.

3. (CONTINUED)

   ROBERTSON STAGE OF DEVELOPMENT MODEL WAS MODIFIED TO ACCOUNT FOR THE EFFECT OF MOISTURE DEFICIENCY ON RATE OF DEVELOPMENT OBSERVED DURING LACIE. EVALUATION INDICATED SIGNIFICANT IMPROVEMENT.

   EFFECTS OF EXCESS MOISTURE ON PLANTING WAS ALSO MODELED AND TESTED. INITIAL RESULTS INDICATED THAT MODEL ACCURATELY PREDICTED MEDIAN PLANTING DATE AND DISTRIBUTION. FURTHER MODIFICATIONS ARE NEEDED TO ACCOUNT FOR THE EFFECTS OF DROUGHT ON PLANTING.

   EXISTING BARLEY STAGE OF DEVELOPMENT MODEL WAS TESTED -- MODEL DID NOT WORK WELL -- STUDIES WERE INITIATED TO IMPROVE MODEL.

4. EXISTING YIELD MODELS WERE STUDIED TO DETERMINE WHERE SPECTRAL INPUT RESEARCH SHOULD BE CONCENTRATED -- SRI, CROP STAGE, MOISTURE STATUS WERE CHOSEN AS FOCUS.

LEVEL I BRIEFING

NOVEMBER 3, 1981

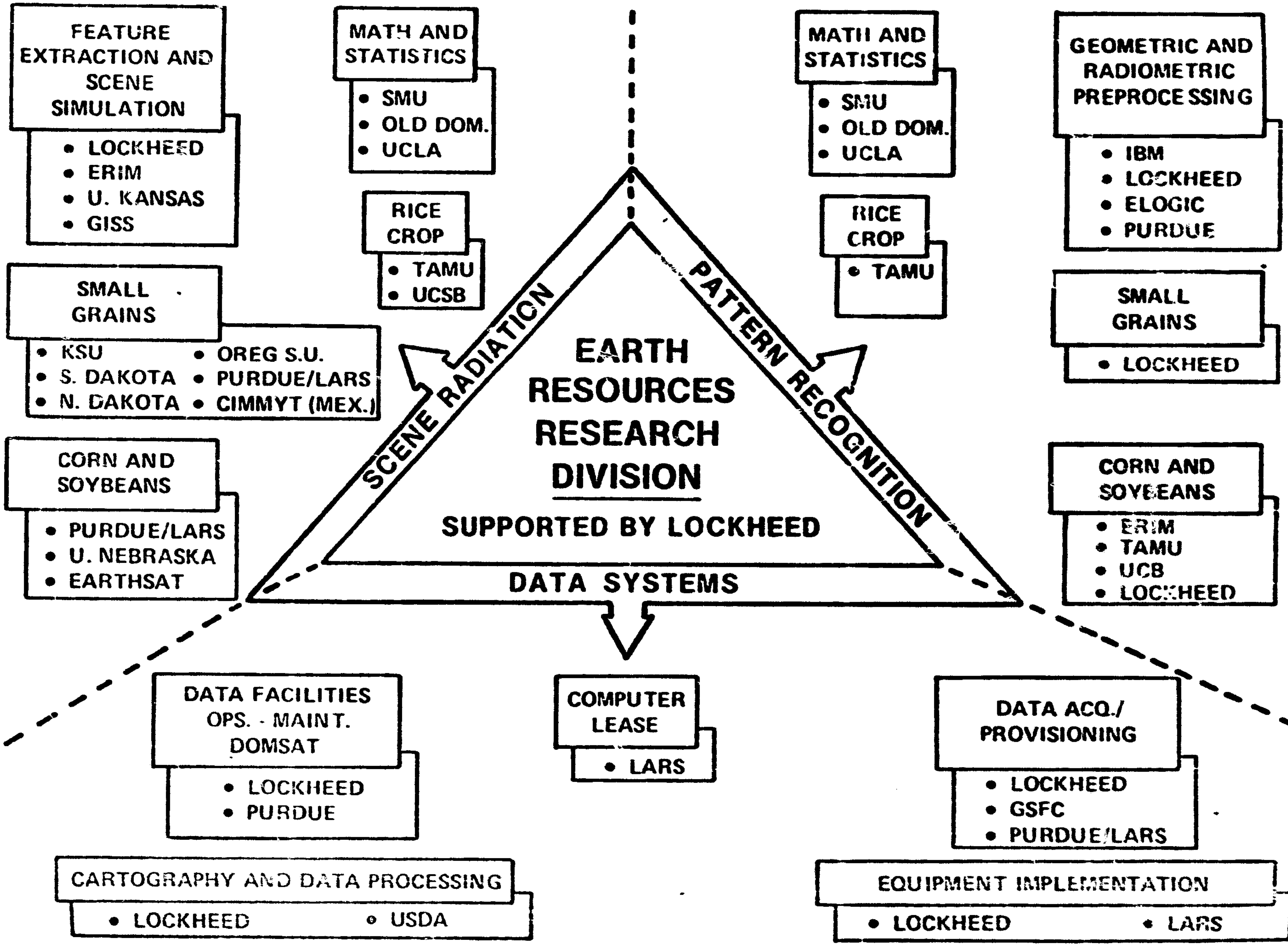
SUPPORTING RESEARCH OVERVIEW

JSC RESEARCH AND DATA SYSTEM SUPPORT

AGRISTARS

| | FY80 | FY81 PRE-APRIL | FY81 POST-APRIL | FY82 POST-APRIL (FY82 PROJECTION) | FY82 CURRENT |
|---|---|---|---|---|---|
| DATA SYSTEMS SUPPORT | 3650 | 3739 | 2664 | 2118 | 1962 |
| RESEARCH | 3324 | 7990 | 4990 | 6462 | 6618 |
| | 6974 | 11729 | 7654 | 8580 | 8580 |

# AgRISTARS APPLIED RESEARCH



LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW



SYNOPSIS OF MAY LEVEL I BRIEFING

SCENE RADIATION

- O MULTITEMPORAL PROFILE MODELS
- O GREENNESS CANOPY PROPERTIES STUDIES
- O BARNES/EXOTECH/MARK II RADIOMETER COMPARISONS
- O TM SIMULATION ACTIVITY
- O SMALL GRAINS PLANTING DATE MODEL TEST
- O WHEAT STAGE DEVELOPMENT MODEL TEST
- O BARLEY STAGE OF DEVELOPMENT MODEL TEST
- O INTERCEPTED SOLAR RADIATION STUDIES
- O ARGENTINA GROUND TRUTH DATA COLLECTION

LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW

SYNOPSIS OF MAY LEVEL I BRIEFING

PATTERN RECOGNITION

- O P1A DESIGN
- O DISTRIBUTION STUDIES OF PROFILE PARAMETERS
- O MIXTURE DECOMPOSITION STUDIES
- O EVALUATION OF SMALL GRAINS PROFILE SEPARABILITY
- O ERIM CORN/SOYBEAN PROCEDURE EVALUATION
- O REGISTRATION

DATA SYSTEMS SUPPORT

- O NEW DATA SYSTEMS RESEARCH SUPPORT FACILITY
- O NEW JSC LANDSAT PROCESSOR
- O REGISTRATION SOFTWARE

GENERAL

- O EXPERIMENT DESIGN/PLANNING FOR FY82/83

LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW

SIGNIFICANT ACTIVITY AREAS SINCE MAY

SCENE RADIATION

- O EVALUATION OF CORN/SOYBEANS SEPARABILITY WITH PROFILE PARAMETERS
- O DEVELOPED A PROFILE BASED CROP EMERGENCE PREDICTOR
- O FIELD TESTED NEW MODULAR MULTIBAND RADIOMETER (MMR)
- O FURTHER EXAMINATION OF ENVIRONMENTAL/CULTURAL FACTORS AFFECTING GREENNESS PROFILES
- O SIMULATION OF MULTIDATE MSS/TM DATA
- O FURTHER TESTING OF SMALL GRAINS PLANTING DATE MODEL/WHEAT AND BARLEY STAGE OF DEVELOPMENT MODELS
- O FURTHER EVALUATION OF SOLAR RADIATION INTERCEPTION (SRI) MODEL
- O FURTHER EVALUATION OF PROFILE BASED STAGE OF DEVELOPMENT ESTIMATOR
- O EVALUATION OF SPECTRALLY DERIVED LAI TO ESTIMATE ET/YIELD
- O INITIATED STUDY OF YIELD FORECAST SENSITIVITY TO SPECTRALLY DERIVED INPUTS

LEVEL I BRIEFING

NOVEMBER 3, 1981

SUPPORTING RESEARCH OVERVIEW

SIGNIFICANT ACTIVITY AREAS SINCE MAY

PATTERN RECOGNITION

- STUDY CONDUCTED TO REASSESS KEY DIRECTIONS IN PATTERN RECOGNITION APPLIED RESEARCH
- APEP PRELIMINARY DESIGN COMPLETE
- DEFINED INITIAL APPROACH TO MULTISEGMENT RESEARCH
- CORN/SOYBEAN PROFILE CLASSIFIER DELIVERED TO FCPF
- FURTHER EVALUATED METHOD FOR ESTIMATING NUMBER OF COMPONENT DISTRIBUTIONS IN SEGMENT DISTRIBUTION FUNCTION
- FURTHER INVESTIGATED SMALL GRAINS SEPARABILITY ACHIEVABLE WITH PROFILE PARAMETERS
- COMPLETED INITIAL INVESTIGATION OF AG ECONOMETRIC MODELS FOR EARLY SEASON ESTIMATES

GENERAL

- DEVELOPED 82/83 RESEARCH PLAN
- HELD TWO QUARTERLY TECHNICAL INTERCHANGE MEETINGS INCLUDING SPECTRAL YIELD INPUTS TO YIELD WORKSHOP.

RADIATION CHARACTERIZATION

SUPPORTING RESEARCH

DAVID E. PITTS

NOVEMBER 3, 1981

# STATUS - SUPPORTING RESEARCH
## SMALL GRAINS
## SCENE RADIATION

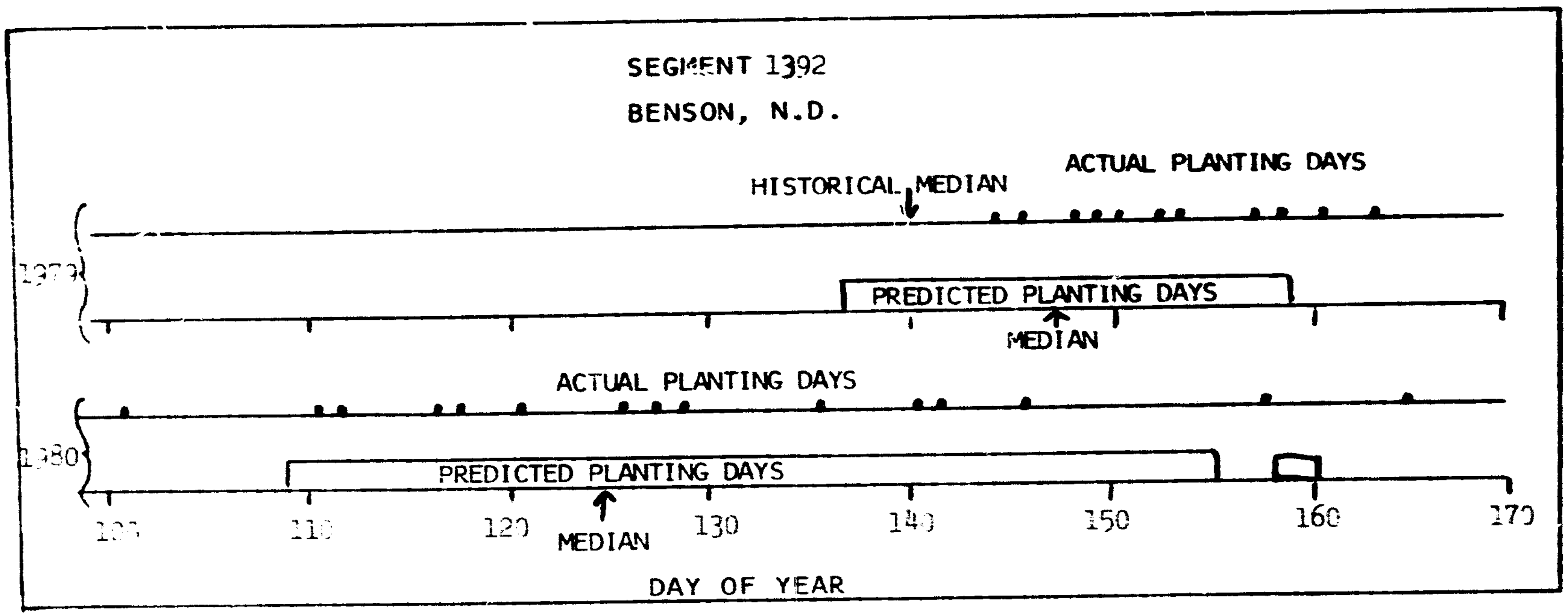
- O SMALL GRAINS RESEARCH PLAN PREPARED.
- O IMPLEMENTATION
  - O CONSORTIUM MEMBERS UNDER CONTRACT
    - O KANSAS STATE UNIVERSITY - LEAD INSTITUTION OF SMALL GRAINS CONSORTIUM
    - O MEMBERS
      - O SOUTH DAKOTA STATE UNIVERSITY
      - O OREGON STATE UNIVERSITY
      - O LEMSCO-JSC
      - O NORTH DAKOTA STATE UNIVERSITY
      - O CIMMYT - AGREEMENT PREPARED
      - O PAN AMERICAN UNIVERSITY
      - O LARS
- O CONSORTIUM MEMBERS ATTENDED THE RADIOMETER WORKSHOP HELD AT LARS.

## PLANTING DATE MODELS (STARTER MODELS)

- O REQUIRED AS A STARTING POINT FOR CROP DEVELOPMENT AND YIELD MODELS AND AS INPUT TO CROP IDENTIFICATION.
- O THREE APPROACHES TO DETERMINE PLANTING DATE
  - \+ NORMAL PLANTING DATE
    - -- STATISTICALLY DERIVED FROM HISTORICAL DATA
    - -- SPECIFIC TO LATITUDE AND CLIMATE
    - -- CANNOT BE UNIVERSALLY APPLIED OVER LARGE AREAS
    - -- DOES NOT ACCOUNT FOR YEAR-TO-YEAR VARIABILITY
  - \+ METEOROLOGICAL MODELS
    - -- USES AVAILABLE METEOROLOGICAL DATA
    - -- ACCOUNTS FOR YEAR-TO-YEAR VARIABILITY
    - -- NOT FIELD SPECIFIC
  - \+ SPECTRAL/MET MODELS
    - -- USES SPECTRAL DATA
    - -- ACCOUNTS FOR FIELD-TO-FIELD VARIABILITY

# METEOROLOGICAL MODEL RESULTS

- A SPRING SMALL GRAINS PLANTING DATE MODEL DEVELOPED TO ACCOUNT FOR TIME AND DURATION OF PLANTING
    - ATTEMPTS TO ACCOUNT FOR PRECIPITATION (TOO WET OR DRY)
- PREVIOUS MODELS ONLY PREDICTED A MEDIAN PLANTING DATE AND DID NOT ATTEMPT TO ACCOUNT FOR LENGTH OF PLANTING OR EFFECT OF PRECIPITATION.
- RESULTS FROM 1979 (WET EARLY), 1980 (DRY), AND 1981 (DRY) SHOWED THAT THE MODEL IMPROVED THE PREDICTION OF THE MEDIAN PLANTING DATE OVER PREVIOUS MODELS; HOWEVER, A PROBLEM EXISTS IN PREDICTING FIRST AND LAST DATES.



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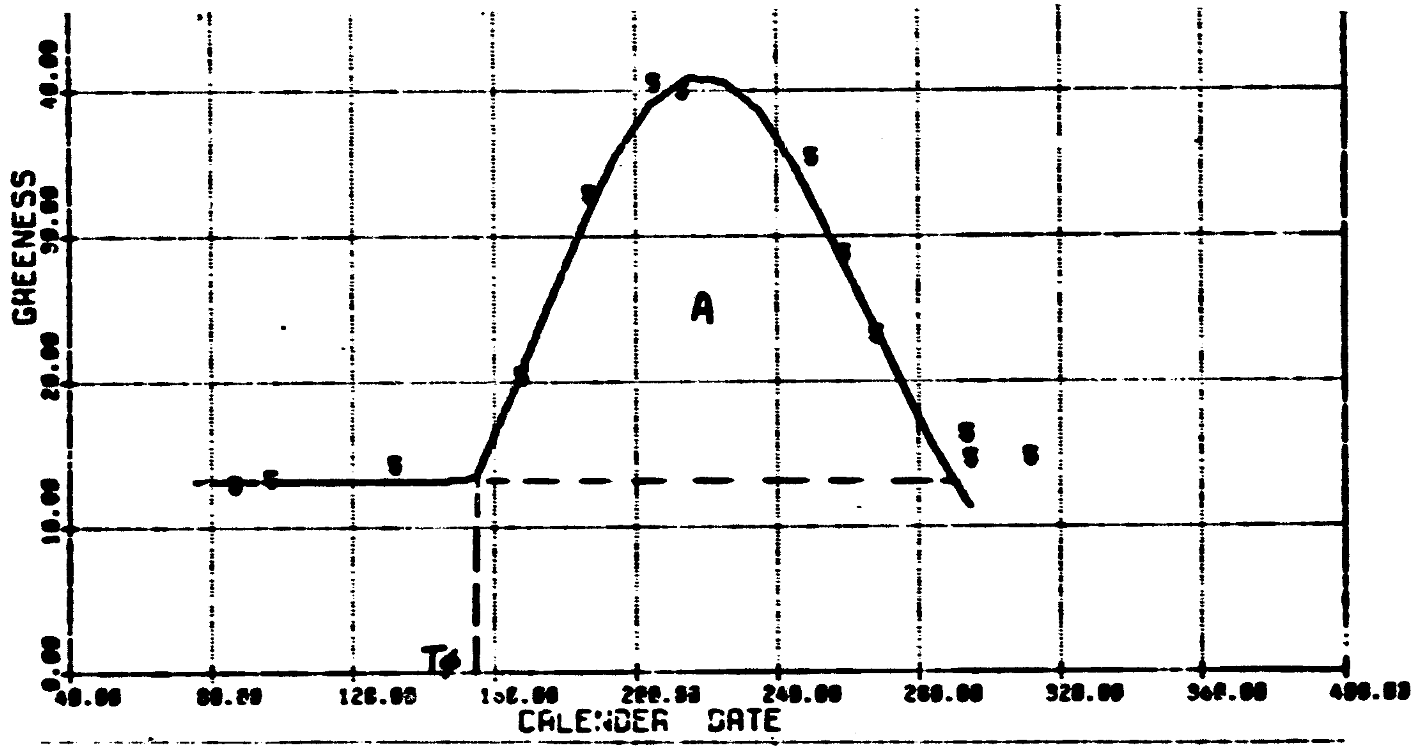
SPECTRAL STARTER RESULTS




- O INITIAL RESULTS FOR 4 SEGMENTS USING PROFILE MODEL INDICATE THAT LANDSAT CAN BE USED FOR DETERMINING EMERGENCE. (30 FIELDS)
  - O To WAS 11.93 $\pm$ 6.32 DAYS AFTER FARMERS PLANTING DATE.
  - O To WAS 1.37 $\pm$ 6.23 DAYS AFTER FARMERS REPORTED EMERGENCE DATE
- O PROVIDES MEANS FOR DETERMINING INDIVIDUAL FIELDS STARTING POINT FOR CROP DEVELOPMENT AND YIELD MODELS.
- O ACCOUNTS FOR FIELD-TO-FIELD VARIABILITY.
- O INITIAL EVALUATION USED ENTIRE PROFILE, HOWEVER, IT IS EXPECTED THAT AN ACCURATE PREDICTION CAN BE MADE BASED ON THE FIRST HALF OF SEASON.

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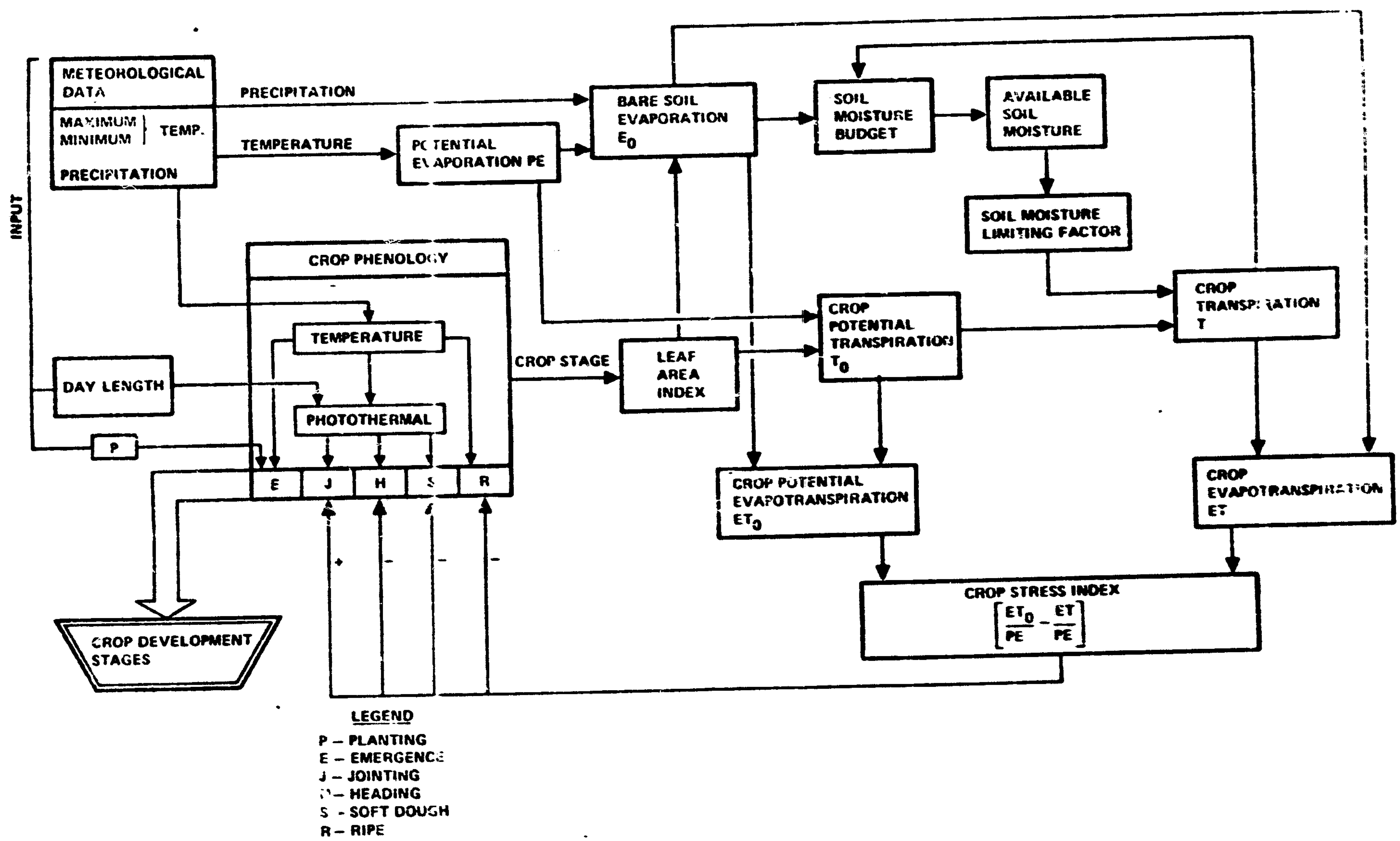
CROP DEVELOPMENT MODELS

O REQUIRED AS A KEY INPUT TO CROP IDENTIFICATION AND YIELD.

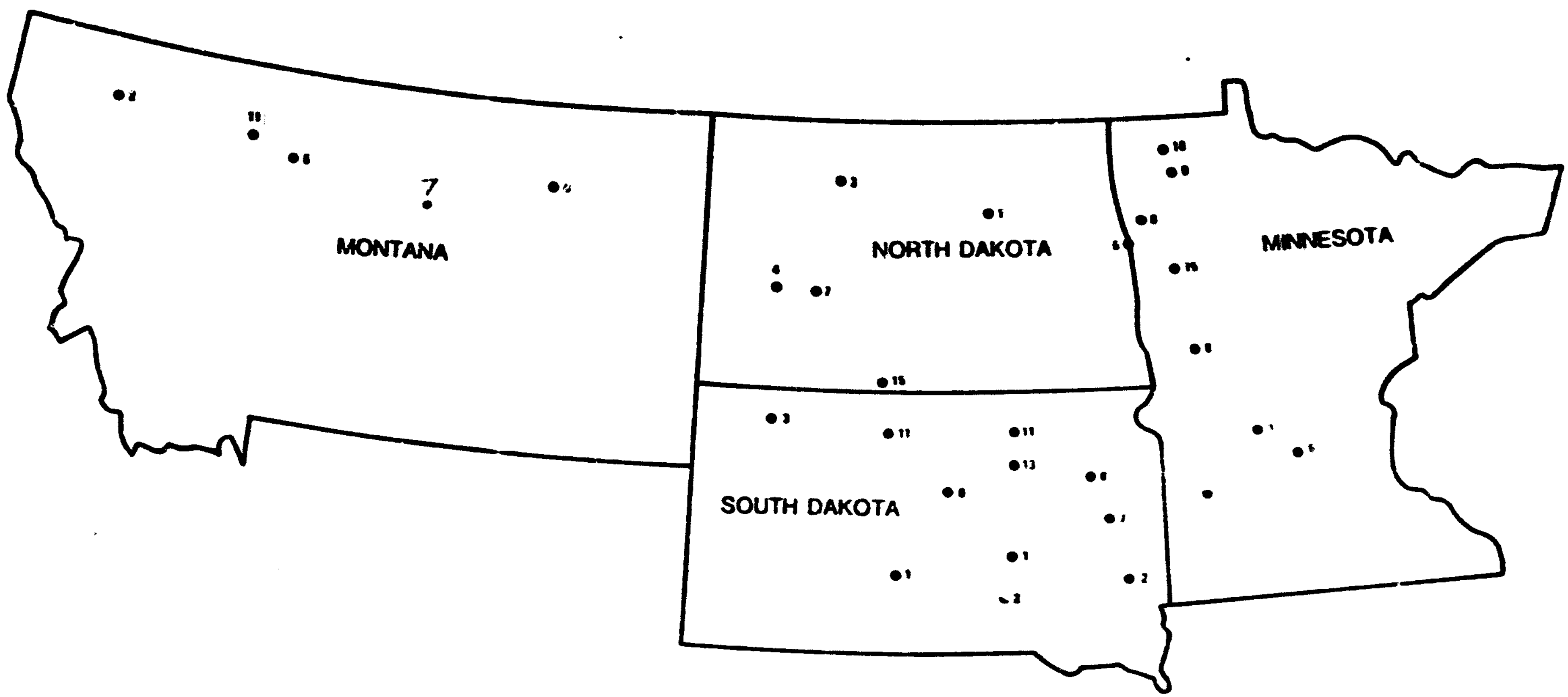
O WHEAT STRESS MODEL WAS DEVELOPED.

  + TO ACCOUNT FOR EFFECT OF MOISTURE ON CROP DEVELOPMENT
  + TO ACCEPT SPECTRAL DATA
    -- NO MODEL EXISTED THAT WOULD ACCEPT SPECTRAL DATA
    -- NECESSARY FOR FIELD LEVEL ESTIMATION OF CROP STAGE/YIELD
  + 1980 TEST RESULTS
    -- RESULTS INDICATE THAT THE WHEAT STRESS MODEL PERFORMED SIGNIFICANTLY BETTER THAN ROBERTSON MODEL, ESPECIALLY AT HEADING AND SEED DEVELOPMENT STAGES.
  + INITIAL EVALUATION USING 1979 LANDSAT DERIVED LAI INDICATED THAT APPROACH FEASIBLE FOR FIELD LEVEL ESTIMATES
  + MODEL REQUESTED BY AND DELIVERED TO USDA-CCAD AND YMD.

SCHEMATIC DIAGRAM OF THE FLOW OF THE MODEL AND THE VARIOUS COMPONENTS IN THE DERIVATION OF THE CROP MOISTURE STRESS INDEX

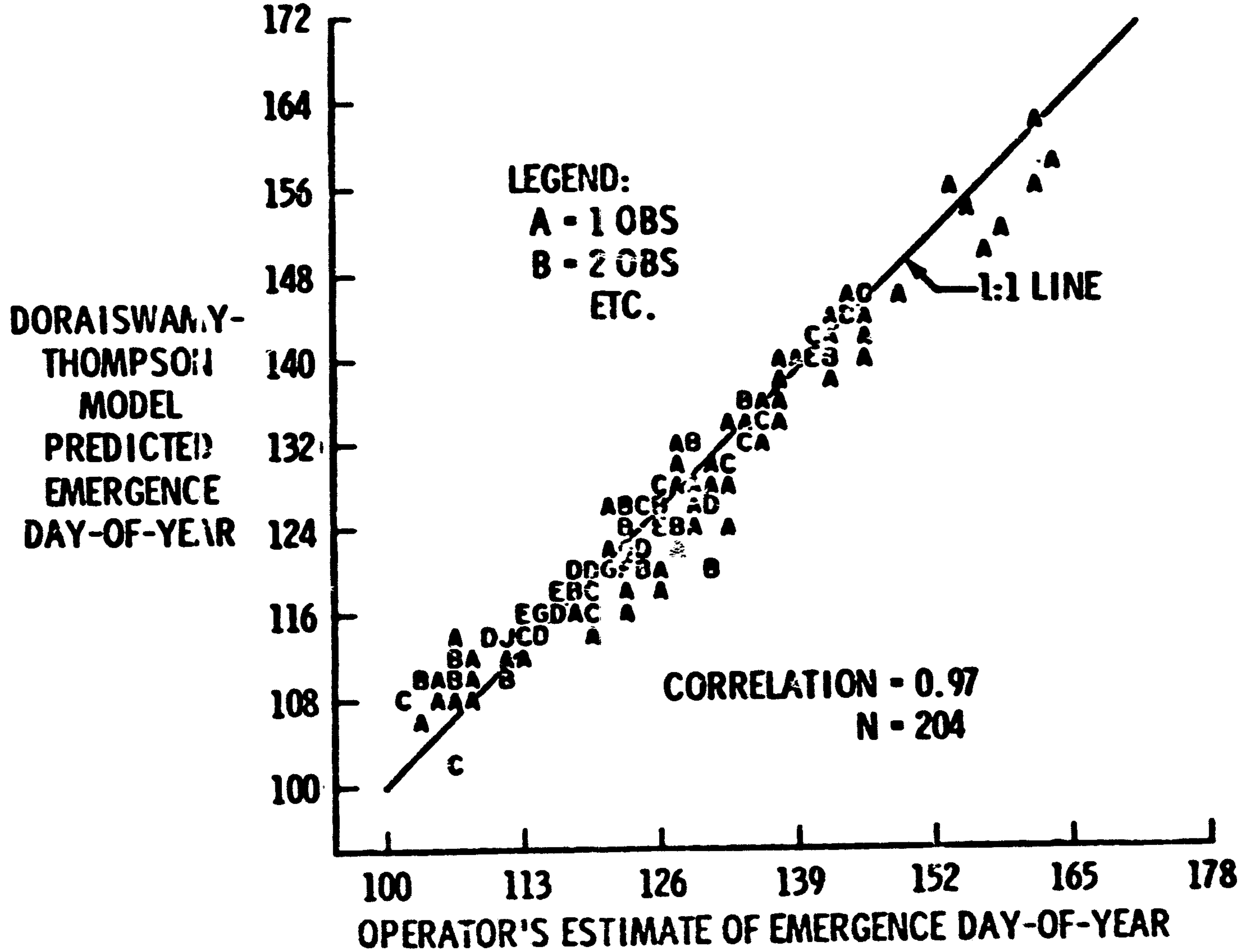


1980 SEGMENT LOCATION AND NUMBER OF FIELDS USED IN CROP DEVELOPMENT TEST



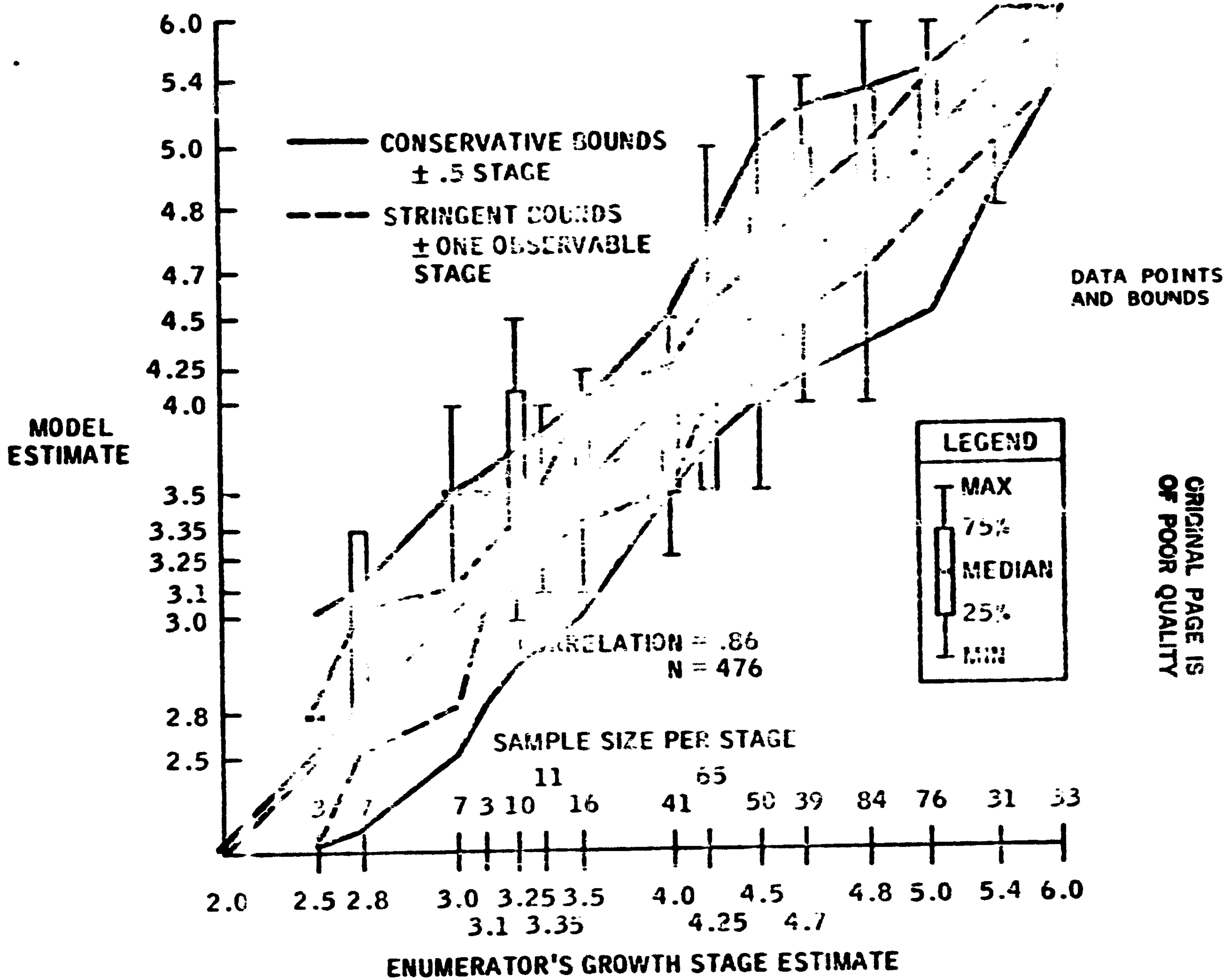
NASA-S-81-11970

# 1980 EMERGENCE DATE PREDICTION PERFORMANCE GIVEN PLANTING DATE FOR SPRING WHEAT FIELDS



NASA-S-81-11969
NASA-S-81-11971

# DORAISWAMY-THOMPSON MODEL
# 1980 GROWTH STAGE PREDICTION PERFORMANCE
## GIVEN PLANTING DATE FOR SPRING WHEAT FIELDS



## SPECTRAL INPUT TO YIELD/CONDITION

- O REMOTELY SENSED DATA PROVIDES A MEANS FOR ESTIMATING KEY AGRONOMIC VARIABLES USED IN YIELD MODELS.

  EXAMPLE: LEAF AREA INDEX, SOIL MOISTURE, PLANTING DATE, CROP STAGES.

- O A YIELD MODEL DEVELOPED BY KANEMASU AND CO-WORKERS HAS BEEN DEVELOPED THAT USES LAI AS AN INPUT TO ESTIMATE EVAPOTRANSPIRATION FOR YIELD.

- O RESULTS INDICATE AN IMPROVEMENT WITH SPECTRAL DATA OVER 137 COMMERCIAL FIELDS.

  + SPECTRAL (LANDSAT MSS) LAI MODEL HAD AN AVERAGE YIELD DIFFERENCE FROM GROUND OBSERVATIONS OF 240 KG/HA OR 3.9 BU/AC.

  + MET MODEL DERIVED LAI HAD AN AVERAGE YIELD DIFFERENCE FROM GROUND OBSERVATIONS OF 840 KG/HA OR 13.9 BU/AC.

## OUTLOOK
## SMALL GRAINS

- O MODELS ARE NOW AVAILABLE (DEVELOPMENT AND YIELD) THAT WILL ACCEPT SPECTRAL DATA.
- O MORE FREQUENT AND MORE PRECISE GROUND OBSERVATIONS ON CROP STAGE NEEDED.
- O EXPECTED RESULTS -- NEAR-TERM
  - O SPECTRAL EMERGENCE "STARTING" DATE MODEL.
  - O INITIAL MODEL FOR PREDICTING SPECTRAL APPEARANCE BASED ON AGRONOMIC CHARACTERISTICS.
  - O COMPLETE EVALUATION OF SPECTRAL INPUT TO YIELD AT A FIELD LEVEL FOR AGRISTARS DATA.
  - O COMPLETE SPECTRAL INPUT TO PHENOLOGY.

## SPECTRAL INPUT TO YIELD WORKSHOP

## OCTOBER 8-9, 1981

O <u>PURPOSE</u>: TO DISCUSS AND DOCUMENT APPROACHES, PROBLEMS AND RESULTS OF SPECTRAL YIELD AND CONDITION RESEARCH.

PRESENTERS INCLUDED USDA, NASA, AND UNIVERSITY RESEARCHERS INVOLVED IN SPECTRAL YIELD RESEARCH: 11 USDA, 2 NOAA, 16 UNIVERSITY, 2 NASA-GISS, AND 3 INDUSTRY.

KEY PAPERS INCLUDED:

- O THE STATUS OF THE USE OF THERMAL DATA IN CROP YIELD AND CONDITION MONITORING
- O AGRONOMIC STRESS AS MEASURED BY SPECTRAL AND THERMAL INDICATIONS
- O STATUS OF MICROWAVE YIELD
- O NORMALIZING ATMOSPHERE EFFECTS ON LANDSAT DIGITAL COUNT DATA OVER TIME
- O LANDSAT VEGETATION INDEX INDICATORS
- O ESTIMATING CANOPY CHARACTERISTICS WITH SPECTRAL AND METEOROLOGICAL DATA
- O USE OF LANDSAT IN WHEAT YIELD MODELS
- O SPECTRAL APPROACHES FOR CROP STAGE
- O A DISCUSSION ON GROUND DATA COLLECTION

<u>BOTTOM LINE</u>: SPECTRAL YIELD RESEARCH IS AT A POINT THAT SIGNIFICANT IMPROVEMENT TO YIELD MODELING CAN BE ACCOMPLISHED.

## STATUS - SUPPORTING RESEARCH
## CORN AND SOYBEANS
## SCENE RADIATION

O CORN/SOYBEAN RESEARCH PLAN PREPARED.

O IMPLEMENTATION:

+ CONSORTIUM MEMBER UNDER CONTRACT
+ LARS LEAD INSTITUTION FOR CORN AND SOYBEANS CONSORTIUM
+ MEMBERS
  -- UNIVERSITY OF NEBRASKA
  -- EARTH SATELLITE CORPORATION

O STATUS ELEMENTS

+ CORN AND SOYBEAN DEVELOPMENT STAGE ESTIMATION
+ UTILIZATION OF SPECTRAL DATA FOR YIELD AND CROP CONDITION ASSESSMENT
+ EVALUATION OF LANDSAT MSS INPUTS TO LARGE SCALE CROP YIELD MODELS
+ TESTING OF BARNES MODULAR MULTIBAND RADIOMETER (MMR) ON HELICOPTER PLATFORMS.

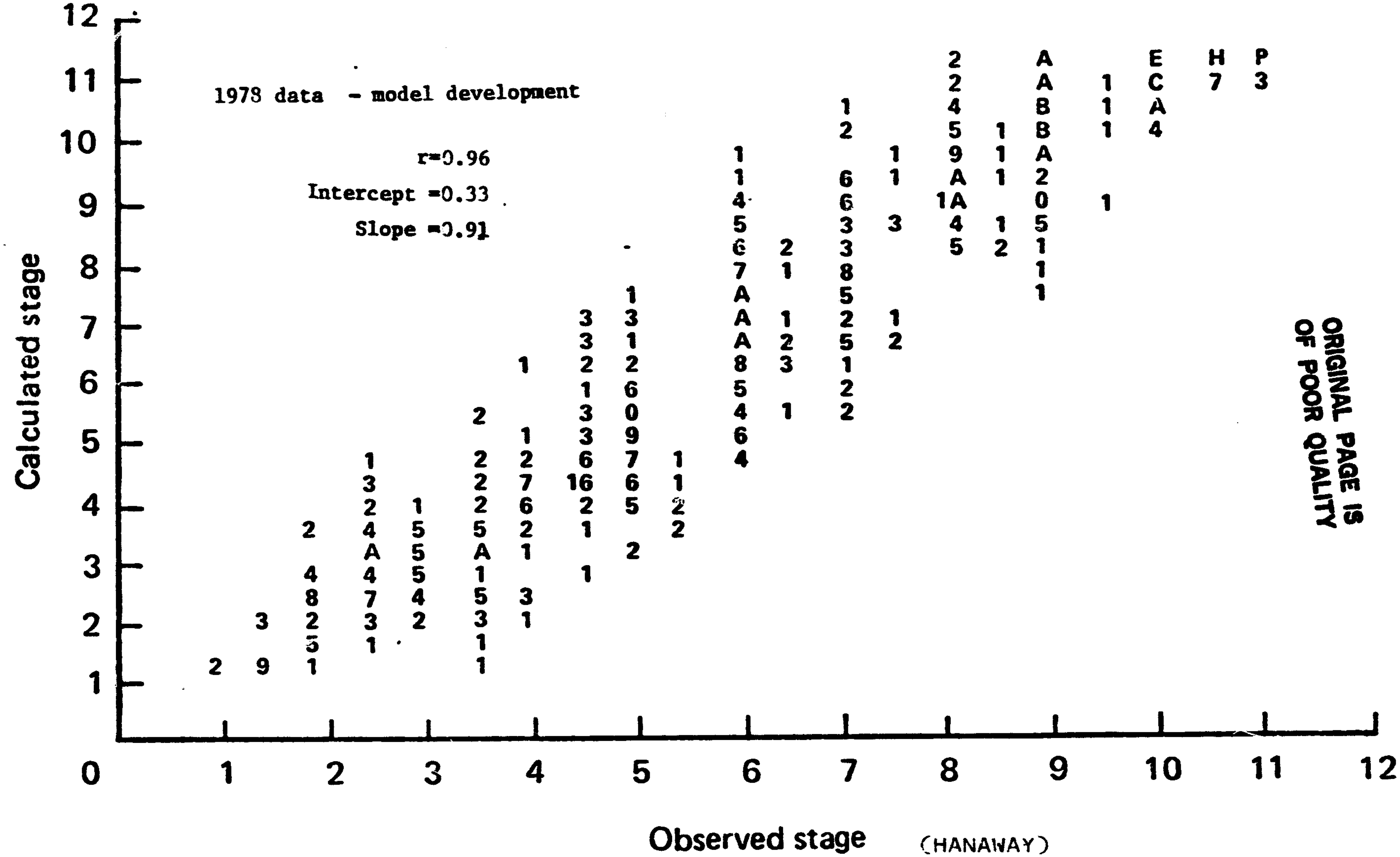
## SUPPORTING RESEARCH - SCENE RADIATION

## CORN AND SOYBEANS

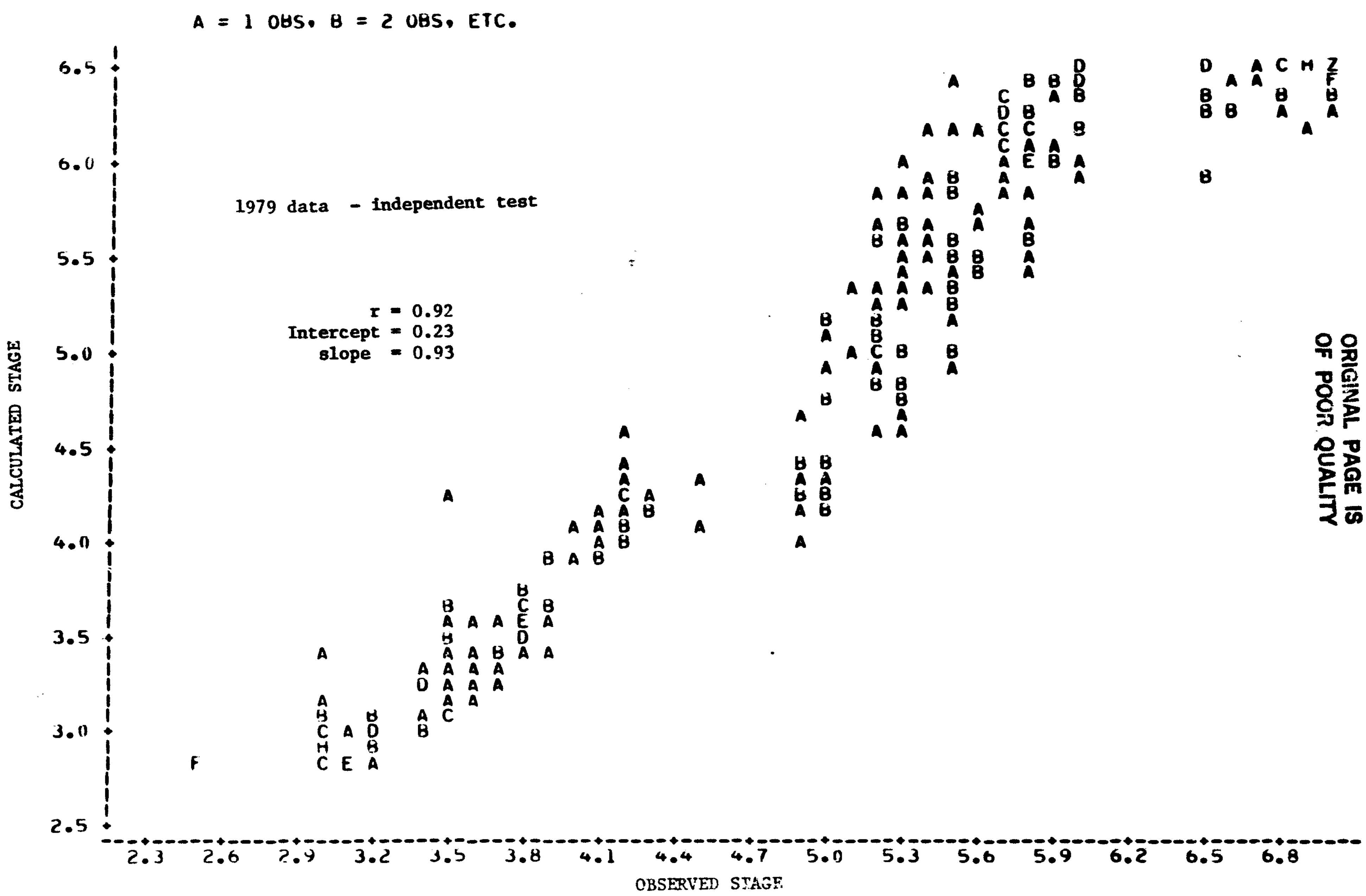
CORN AND SOYBEAN DEVELOPMENT STAGE ESTIMATION

- O TECHNICAL STATUS
  - \+ CONCEPT UTILIZING SPECTRAL PROFILE MODELS EXPANDED
    - -- ADDITIONAL YEARS TESTING (1979 LANDSAT DATA)
    - -- WIDER GEOGRAPHIC REGION (NORTH AND SOUTH CAROLINA)
    - -- MODIFIED FOR ADDITIONAL CROPS (SOYBEANS)
  - \+ RESULTS OF 1979 TEST VERIFIED ENCOURAGING RESULTS USING 1978 DATA
    - -- SIMILAR OVERALL ACCURACY
    - -- SIMILAR BEHAVIOR FOR INDIVIDUAL STAGES
    - -- IS APPLICABLE TO SOYBEANS--NOT EXAMINED TO SAME EXTENT AS FOR CORN
- O OUTLOOK
  - \+ MODEL BEING INCLUDED IN OTHER SR TASKS (EVALUATED AS CROP STAGE ESTIMATOR IN LARS/EARTHSAT EFFORT)
  - \+ ADDITIONAL DATA PRIOR TO PEAK GREENNESS BEING EXAMINED TO SUPPORT EARLY SEASON WORK
  - \+ ADDITIONAL TESTING FOR SOYBEANS AND EXTEND CONCEPT TO SMALL GRAINS.

CROP STAGE FOR CORN ESTIMATED FROM MSS DATA

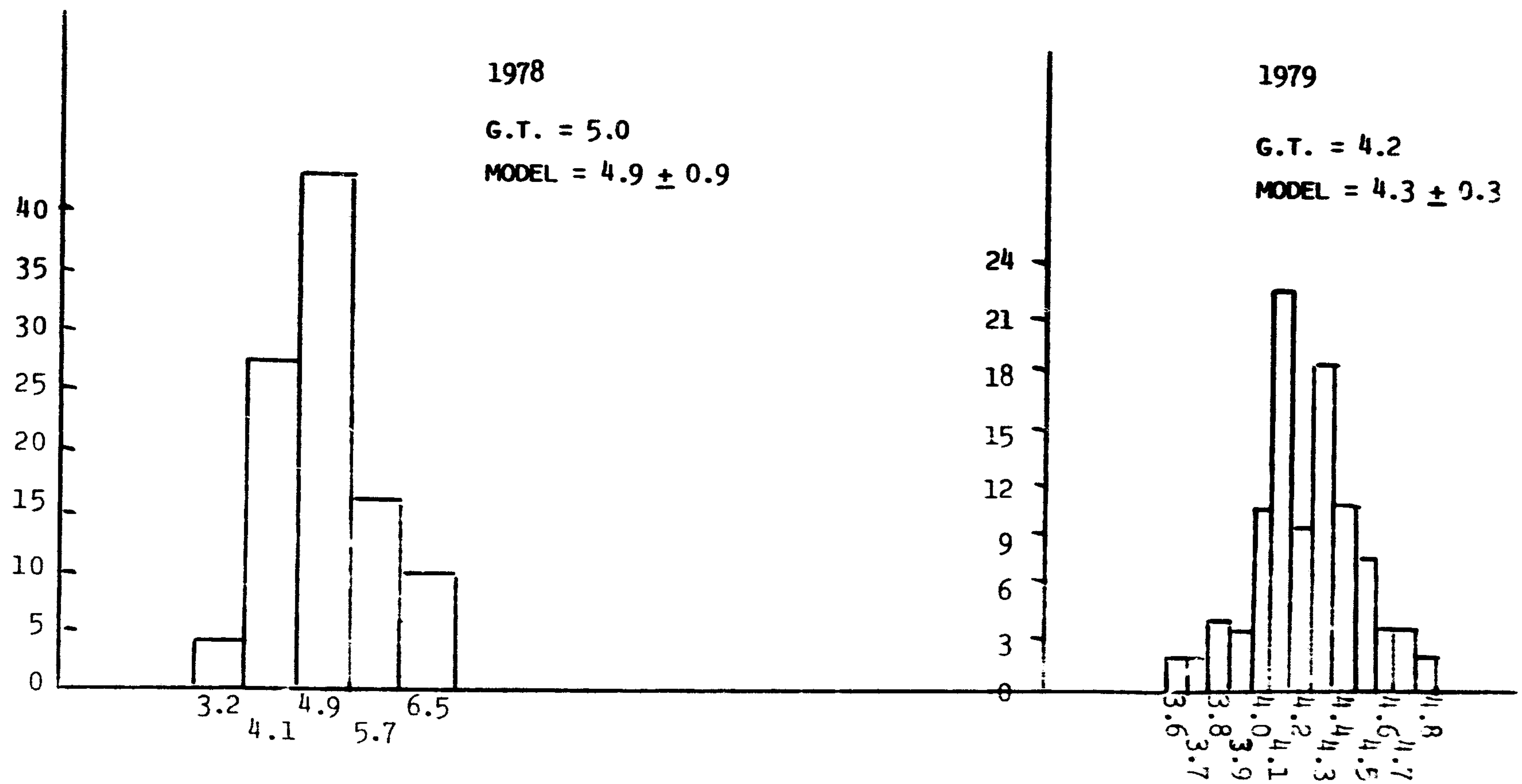


CROP STAGE FOR CORN ESTIMATED FROM MSS DATA



COMPARISON OF 1978 AND 1979 DATA ANALYSIS RESULTS

FOR ONE KEY DEVELOPMENT STAGE (SILKING)



## SUPPORTING RESEARCH - SCENE RADIATION
## CORN AND SOYBEANS

UTILIZATION OF SPECTRAL DATA FOR YIELD AND CROP CONDITION ASSESSMENT

O TECHNICAL STATUS

+ AGRONOMIC VARIABLES THAT ARE IMPORTANT TO YIELD AND HAVE POTENTIAL FOR ESTIMATION BY REMOTE SENSING HAVE BEEN EXAMINED.

  BIOMASS ACCUMULATION, % GROUND COVER, LEAF AREA INDES, SOIL ORGANIC MATTER

+ CURRENT FOCUS ON DETERMINING SOLAR RADIATION INTERCEPTED AS A FUNCTION OF LEAF AREA INDEX.

## SUPPORTING RESEARCH - SCENE RADIATION

### CORN AND SOYBEANS

SUMMARY OF RESULTS - YIELD VARIATION EXPLAINED BY VARIOUS YIELD MODEL COMPONENTS.

DATA FROM PURDUE AGRONOMY FARM, CORN CULTURAL EXPERIMENT, 1979 AND 1980.

| MODEL COMPONENTS | INPUT DATA DESCRIPTION | $R^2$ (N=81) |
|---|---|---|
| MAXIMUM GREENNESS | SPECTRAL DATA ONLY | 0.23 |
| $\sum$ TEMPERATURE AND WATER STRESS | METEOROLOGICAL DATA ONLY | 0.59 |
| $\sum$ SRI | DERIVED FROM MEASURED LAI | 0.67 |
| $\sum$ SRI | DERIVED FROM SPECTRAL DATA | 0.64 |
| CROP GROWTH MODEL | CONTAINS METEOROLOGICAL DATA AND MEASURED LAI | 0.68 |
| CROP GROWTH MODEL | METEOROLOGICAL AND SPECTRAL LAI | 0.70 |

INCORPORATION OF SPECTRAL DATA PROVIDES MORE INFORMATION ABOUT YIELD THAN METEOROLOGICAL DATA ALONE.

SPECTRALLY DERIVED PARAMETERS (LAI) PERFORMS JUST AS WELL AS GROUND MEASURED LAI.

# SUPPORTING RESEARCH - SCENE RADIATION
## CORN AND SOYBEANS

EVALUATION OF LANDSAT SPECTRAL INPUTS TO LARGE SCALE MODELS

O TECHNICAL STATUS

+ SENSITIVITY ANALYSIS BEING CONDUCTED TO DETERMINE MODEL SENSITIVITY TO PLANTING DATE, SPECTRAL VARIABLES (LAI, ALBEDO) AND CROP STRESS FACTORS.

| | FREQUENCY OF YIELD ERROR OF 5% OR GREATER | |
|---|---|---|
| PLANTING DATE ERROR | CORN | SOYBEANS |
| 4 DAYS | 20% | 5% |
| 10 DAYS | 30% | 15% |

O OUTLOOK

+ DETERMINE IF SPECTRAL PLANTING DATES FROM BADHWAR PROFILE MODELS CAN PROVIDE DESIRED PRECISION AND IMPROVE CURRENT YIELD ESTIMATES

+ INCORPORATE ADDITIONAL SPECTRAL VARIABLES (ALBEDO) AND DETERMINE MODEL SENSITIVITY.

## SUPPORTING RESEARCH - SCENE RADIATION
## CORN AND SOYBEANS

FIELD TESTING OF MODULAR MULTIBAND RADIOMETER ON HELICOPTER PLATFORM

| TEST # | INSTRUMENTATION | LOCATION | DATE |
|---|---|---|---|
| 1A | JET RANGER HELICOPTER<br>FILTERWHEEL SPECTROMETER<br>MMR<br>CAMERA | WEBSTER CO., IOWA | 9/18/81 |
| 1B | (SAME AS 1A) | CASS CO., NORTH DAKOTA | 9/21/81 |
| 2 | SMALL BELL HELICOPTER<br>MMR<br>CAMERA | WHARTON, CO., TEXAS | 10/19/81 |

OUTLOOK

+ DRAWINGS, SPECIFICATIONS, PROCEDURES FOR MOUNTING INSTRUMENT BEIND DOCUMENTED FOR TWO CONFIGURATIONS THAT ARE COMMONLY AVAILABLE.

+ WILL ALLOW USER TO ACQUIRE DATA FROM EHLICOPTER PLATFORM FOR MODEST COST.

NASA National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

NASA S-81-12318

# FIELD TEST OF MODULAR MULTIBAND RADIOMETER

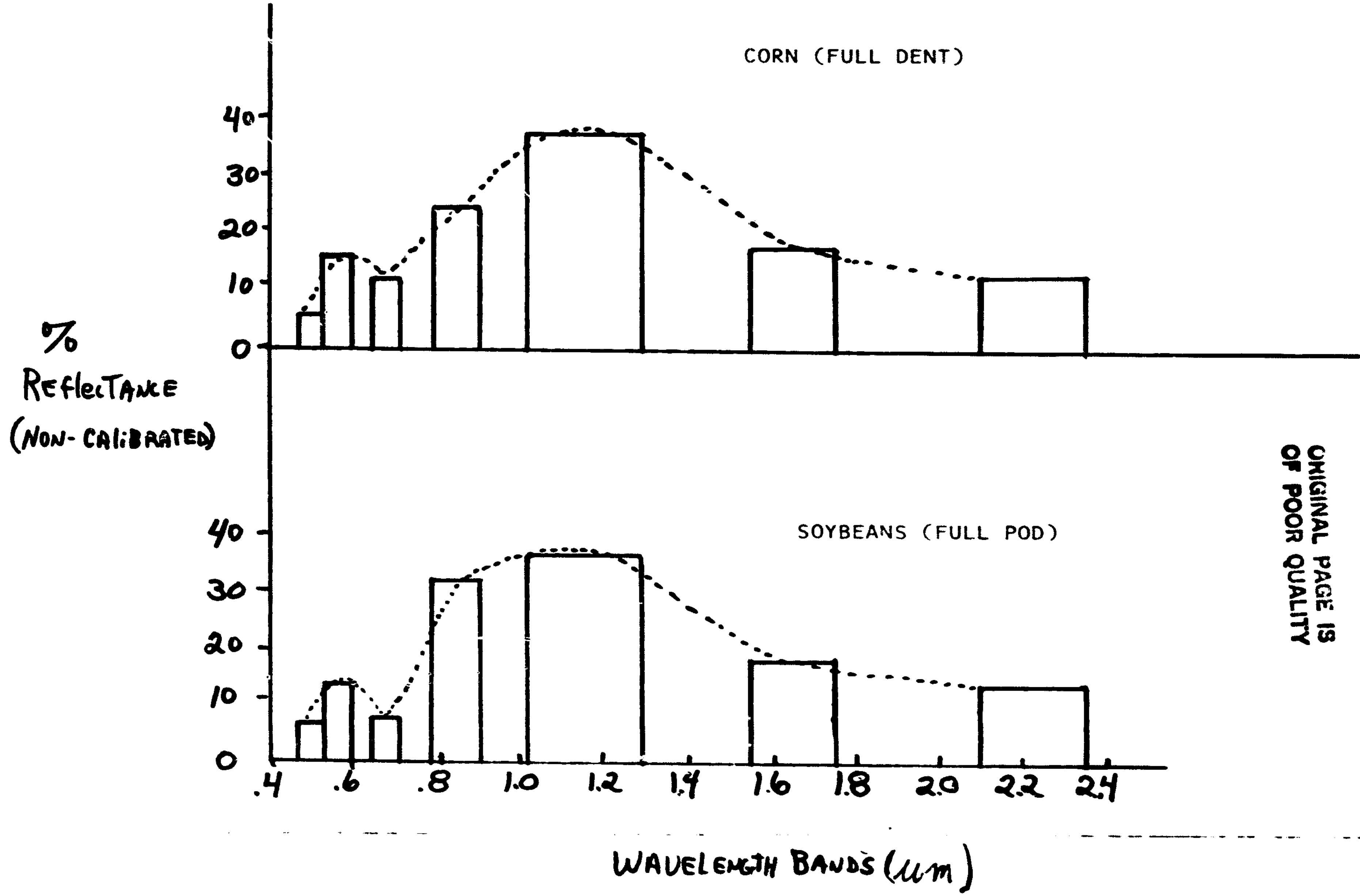
## WEBSTER COUNTY, IOWA
## SEPTEMBER 16, 1981

MULTIBAND RADIOMETER AND FIELD SPECTROMETER ON JET RANGER

DATA LOGGER SYSTEM FOR MULTIBAND RADIOMETER

CALIBRATION PROCEDURE

WEBSTER CO., IOWA -- SEPTEMBER 18, 1981



**SAMPLE OF DATA ACQUIRED BY MMR DURING**
**TEST 1A, WEBSTER CO., IOWA, SEGMENT 893**

| SCENE IDENTIFICATION | BAND 1 .45-.52 | BAND 2 .52-.6[illegible] | BAND 3 .63-.69 | BAND 4 .76-.90 | BAND 5 [illegible] | BAND 6 [illegible] | BAND 7 [illegible].35 | BAND 8 10.4-12.5 |
|---|---|---|---|---|---|---|---|---|
| CALIBRATION PANEL | .529 | .990 | .653 | .655 | .747 | .521 | .539 | 1.901 |
| | .528 | .991 | .652 | .655 | .747 | .521 | .541 | 1.838 |
| | .526 | .983 | .650 | .656 | .752 | .523 | .546 | 1.864 |
| | .515 | .986 | .642 | .650 | .750 | .525 | .549 | 1.838 |
| CORN FIELD | .047 | .134 | .091 | .282 | .368 | .174 | .133 | 1.047 |
| | .048 | .138 | .096 | .281 | .369 | .184 | .138 | 1.048 |
| | .051 | .139 | .102 | .271 | .374 | .192 | .150 | 1.049 |
| | .054 | .148 | .112 | .174 | .383 | .200 | .156 | 1.050 |
| SOYBEAN FIELD | .050 | .127 | .077 | .318 | .351 | .171 | .116 | 1.054 |
| | .050 | .126 | .078 | .301 | .334 | .166 | .106 | 1.054 |
| | .050 | .127 | .077 | .316 | .347 | .168 | .114 | 1.055 |
| | .051 | .131 | .081 | .321 | .363 | .179 | .120 | 1.055 |

ORIGINAL PAGE IS
OF POOR QUALITY

## SCENE SIMULATION AND ANALYSIS CONSORTIUM

PURPOSE

O DEVELOPMENT OF SPECTRAL DATA SIMULATION CAPABILITY FOR

+ UNDERSTANDING OF THE PERFORMANCE OF ALGORITHMS APPLIED TO SPECTRAL DATA
+ DETERMINATION OF THE USEFULNESS OF PROPOSED SENSORS
+ DEVELOPMENT OF CRITERIA FOR PROPOSED SENSORS

O EXTRACTION OF GENERAL FEATURES FROM SPECTRAL DATA PRODUCED BY EXISTING AND PROPOSED SENSOR SYSTEMS FOR USE IN

+ CROP IDENTIFICATION
+ CROP DEVELOPMENT STAGE ESTIMATION
+ CROP CONDITION ASSESSMENT

ORGANIZATION

O NASA/JSC -- CONSORTIUM COORDINATION
-- DETERMINATION OF FEATURES FOR CROP IDENTIFICATION

O LOCKHEED -- SIMULATION SYSTEM DESIGN AND IMPLEMENTATION
-- DEVELOPMENT OF SIMULATION APPROACH USING FIELD MEASUREMENT DATA.
-- EVALUATION OF EFFECT OF SIGNATURE MIXING ON ALGORITHM PERFORMANCE

## SCENE SIMULATION AND ANALYSIS CONSORTIUM (CONT.)

ORGANIZATION (CONT.)

- O ERIM
  - -- DEVELOPMENT OF PHYSICAL MODELING APPROACH TO SIMULATION
  - -- DETERMINATION OF FEATURES IN TM AND MSS SPECTRAL DATA FOR CROP IDENTIFICATION
  - -- DETERMINATION OF THE DEPENDENCE OF MSS SPECTRAL FEATURES ON CROP CHARACTERISTICS
- O GISS
  - -- DEVELOPMENT OF EMPIRICAL SIMULATION APPROACH USING AIRBORNE SENSORS
  - -- INVESTIGATION OF WITHIN FIELD SIGNATURE VARIABILITY
  - -- DETERMINATION OF FEATURES IN TM DATA FOR CROP IDENTIFICATION



CURRENT STATUS

- O MOST OF THE COMPONENTS NEEDED FOR USABLE SIMULATION CAPABILITY HAVE BEEN DEVELOPED
  - -- TECHNIQUES FOR CREATING SPECTRAL BAND COUNTS FROM FIELD MEASUREMENT DATA.
  - -- TECHNIQUES FOR PROCESSING AIRBORNE SENSOR DATA INTO SIMULATED SCENES
  - -- TECHNIQUES FOR PRODUCING SPECTRAL REFLECTANCE DATA USING PHYSICAL MODELS FOR CROP CHARACTERISTICS AND CANOPY SPECTRAL RESPONSE.
- O SOME STUDIES FOR FEATURE EXTRACTION HAVE BEEN PERFORMED.
  - -- INCORPORATION OF BRIGHTNESS INFORMATION INTO TEMPORAL PROFILING
  - -- STUDY OF AGRONOMIC EFFECTS ON VARIOUS FEATURES OF MSS TEMPORAL PROFILES
  - -- EVALUATION OF WITHIN FIELD VARIABILITY FOR TM DATA
  - -- EVALUATION OF THE USEFULNESS OF ADDITIONAL TM BANDS IN CROP IDENTIFICATION.

## SCENE SIMULATION AND ANALYSIS CONSORTIUM (CONT.)

EXPECTED RESULTS FOR COMING FISCAL YEAR

- DEVELOPMENT AND IMPLEMENTATION OF SYSTEM FOR SIMULATION
- STUDY OF THE EFFECT OF MIXED SIGNATURES ON ALGORITHM PERFORMANCE
- IMPROVEMENT OF BOTH EMPIRICAL AND PHYSICAL SIMULATION CAPABILITIES
- PROCESSING OF MULTIDATE SIMULATED TM DATA FOR USE IN PERFORMANCE EVALUATION

MULTITEMPORAL THEMATIC MAPPER SPECTRAL DATA SIMULATION

- INPUT SPECTRAL RESPONSE FROM FIELD MEASUREMENT DATA.
- PROFILE FITTING TO INTERPOLATE BETWEEN DATES WHEN MEASUREMENTS WERE MADE.
- PROFILES SHIFTED TO SIMULATE VARIATION IN PLANTING DATE.

## PROCESSING OF NS001 AIRBORNE SPECTROMETER DATA INTO SIMULATED TM SCENE

- O CONVERTS AIRBORNE SENSOR DATA INTO EQUIVALENT SCENE AS IT WOULD BE SEEN FROM A SATELLITE.

- O RELIES ON SCENE CHARACTERISTIC TO PERFORM TRANSFORMATION RATHER THAN DETAILED AIRCRAFT PARAMETERS

- O MAJOR STEPS IN PROCESSING

  --RADIOMETRIC ADJUSTMENTS

  + COMPENSATE FOR INSTRUMENT VARIATION
  + ADJUST FOR SCAN-ANGLE EFFECTS

  --RECTIFICATION TO MAP BASE

  + DIGITIZE GROUND CONTROL POINTS
  + APPLY NONLINEAR GLOBAL TRANSFORMATION
  + REFINE WITH LOCAL CORRECTION

  --INCLUSION OF OBSERVING SYSTEM PARAMETERS

  + CONVERT OF INSTRUMENT COUNTS
  + ROTATE TO LANDSAT ORIENTATION
  + RESAMPLE TO SELECTED IFOV

## ISSUES TO BE STUDIED USING SIMULATION CAPABILITY



SPECTRALLY MIXED PIXELS

- O WHAT ERRORS ARE INTRODUCED INTO PROPORTION ESTIMATES IF SPECTRALLY MIXED PIXELS ARE NOT CONSIDERED IN CALCULATING THE PROPORTIONS?
- O HOW CAN ERRORS BE REDUCED BY USING IMAGE ANALYSIS AND ENHANCEMENT TECHNIQUES TO HANDLE MIXED PIXELS?
- O WHAT IS THE EFFECT OF SPECTRALLY MIXED PIXELS ON THE EXTRACTION OF PARAMETERS FROM TEMPORAL PROFILES?
- O HOW DOES MISREGISTRATION EFFECT THE ABILITY TO ESTIMATE PROFILE CHARACTERISTICS?
- O WHAT IS THE EFFECT OF MIXED PIXELS ON THE DISTRIBUTIONS OF PROFILE CHARACTERISTICS?
- O WHAT IS THE MOST EFFECTIVE WAY OF DETECTING MIXED PIXELS?
- O AS SENSOR RESOLUTION IS IMPROVED, HOW MUCH ARE THE EFFECTS OF SPECTRALLY MIXED PIXELS REDUCED?

## ISSUES TO BE STUDIED USING SIMULATION CAPABILITY
## (CONTINUED)

### TEMPORAL SAMPLING

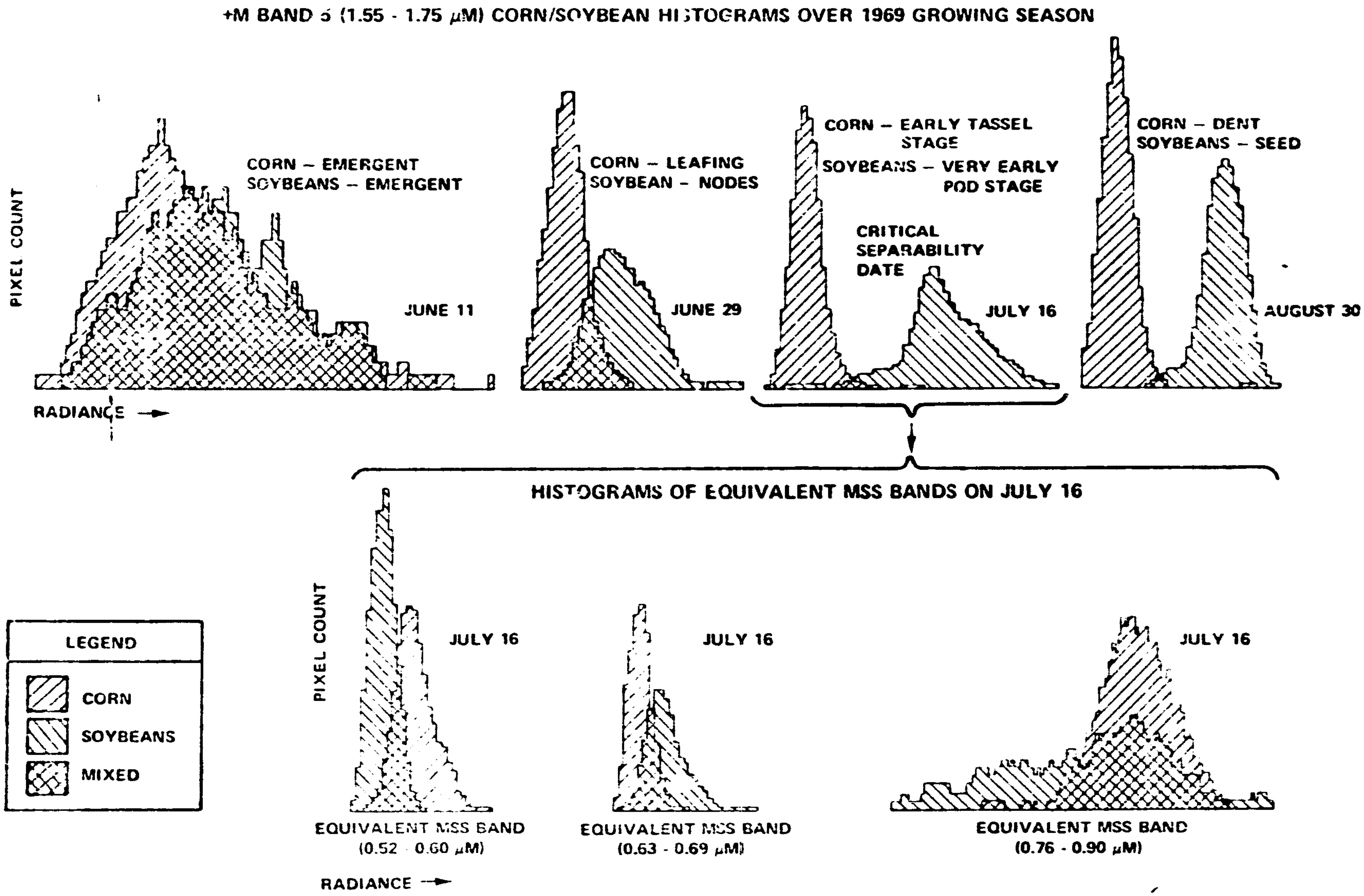
- O HOW OFTEN MUST THE SPECTRAL RESPONSE BE SAMPLED IN ORDER TO ACCURATELY ESTIMATE CHARACTERISTICS OF THE TEMPORAL PROFILE?
- O WHAT REDUCTION IN THE ACCURACY OF THE PROFILE CHARACTERISTIC ESTIMATES OCCURS WHEN ONLY PART OF THE PROFILE IS SAMPLED?
- O ARE THERE CRITICAL PERIODS IN THE PROFILES WHICH MUST BE SAMPLED IN ORDER TO GET GOOD ESTIMATES OF THE CHARACTERISTICS?
- O HOW ACCURATE DO THE WINDOW DEFINITIONS USED BY VARIOUS ALGORITHMS NEED TO BE TO PRODUCE ACCEPTABLE RESULTS.

### PROPOSED SENSOR SYSTEMS

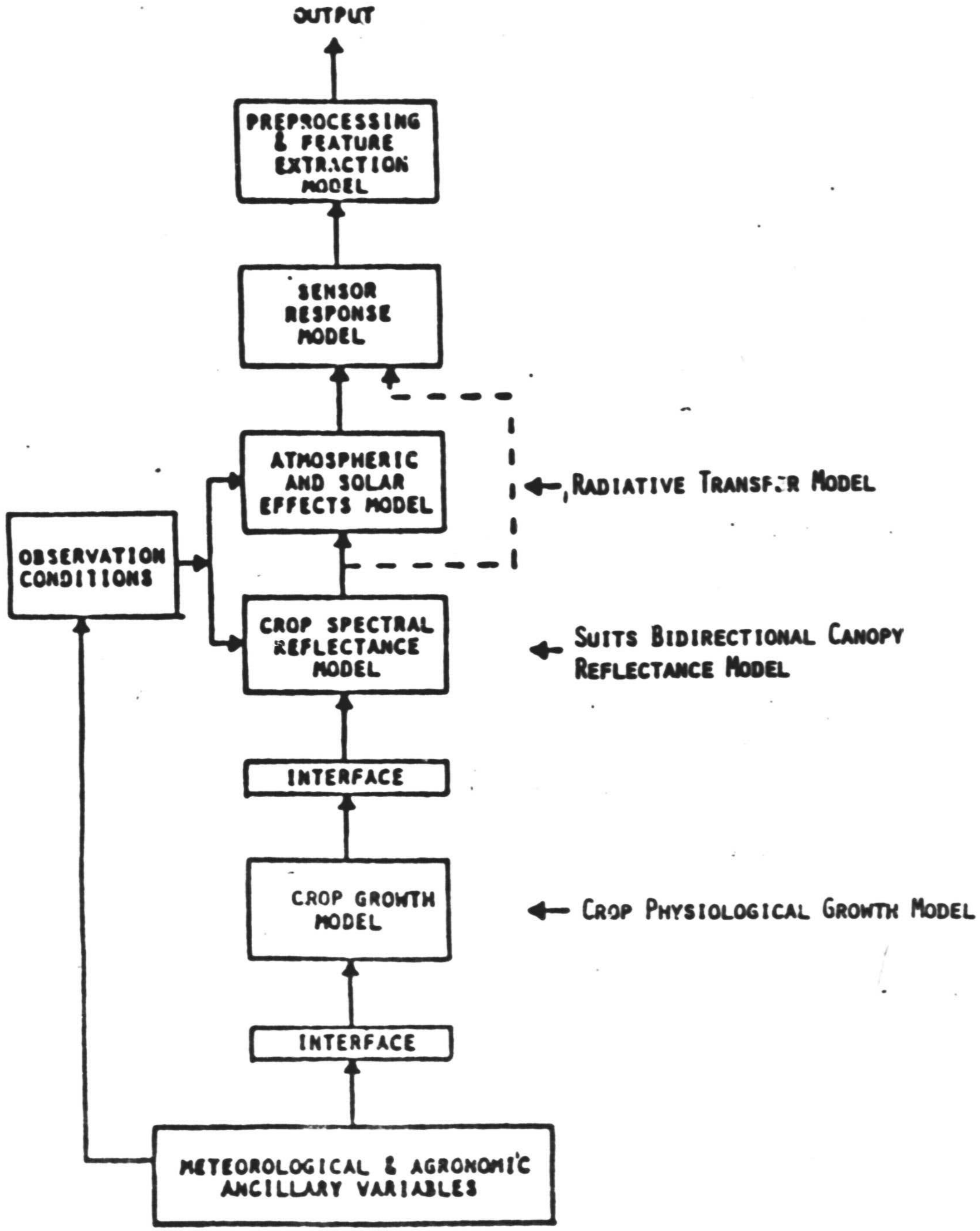
- O HOW WILL THE ADDITIONAL BANDS AVAILABLE ON THE THEMATIC MAPPER EFFECT THE ABILITY TO IDENTIFY CROPS AND DETERMINE CROP CONDITION?

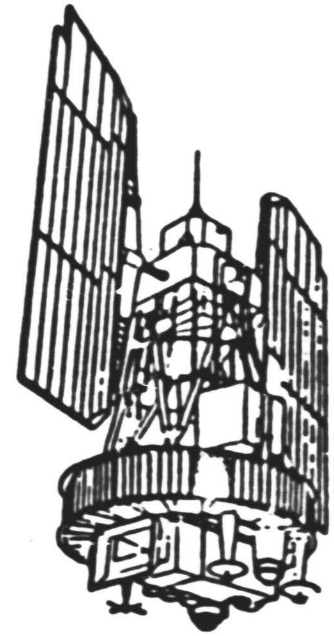
# CORN/SOYBEAN SEPARABILITY

## THEMATIC MAPPER BANDS (1.55 - 1.75 μM) OUTPERFORMS MSS BANDS IN CORN/SOYBEAN SEPARATION TEST (HISTOGRAMS BASED ON 1979 FIELD SPECTROMETER SYSTEM DATA FROM WEBSTER COUNTY, IOWA TEST SITE)

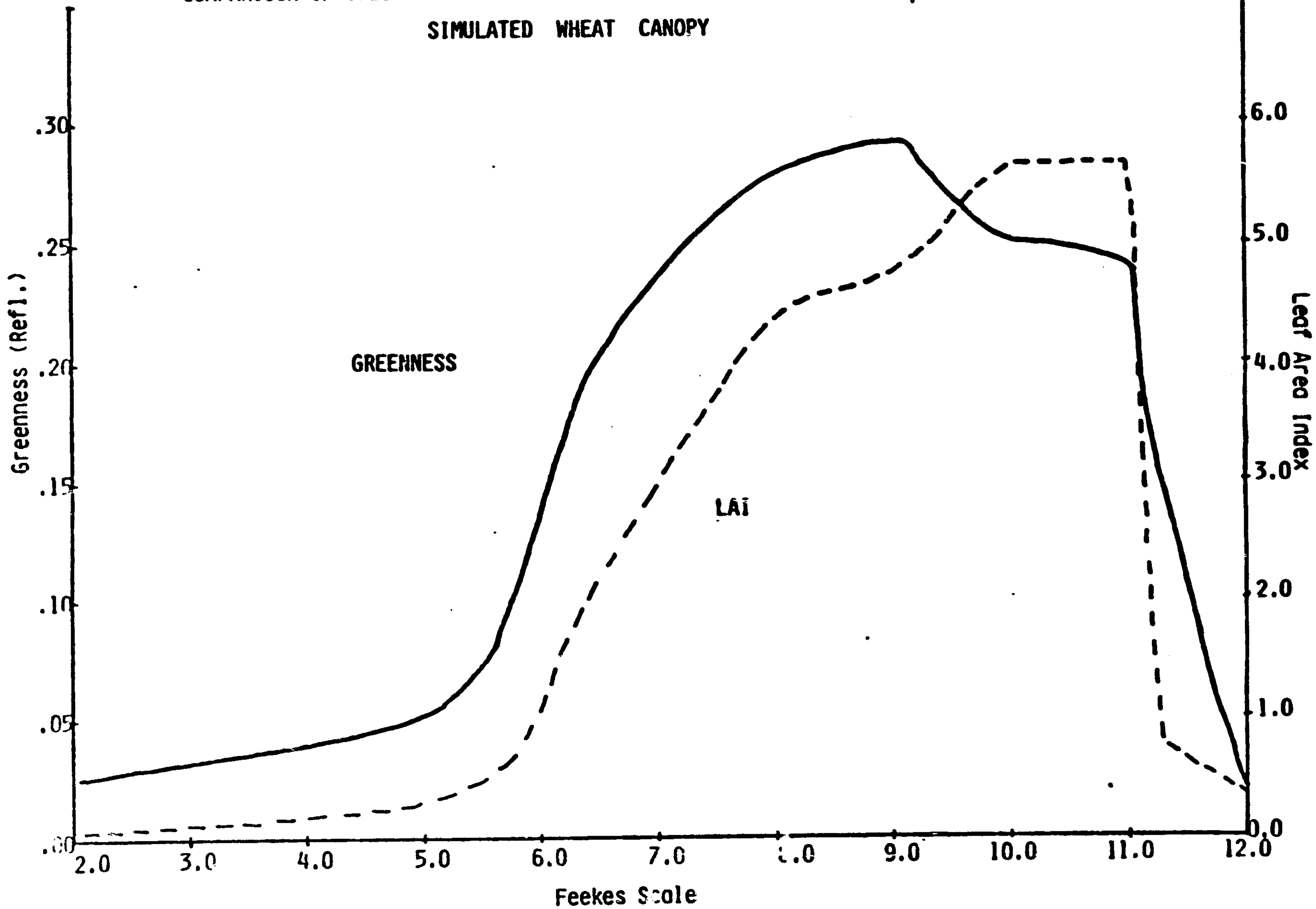


# "SEED-TO-SATELLITE" MODEL



COMPARISON OF GREENNESS AND LEAF AREA INDEX (versus Feekes Scale) FOR SIMULATED WHEAT CANOPY



TASK 21-23: SCENE ANALYSIS (FEATURE EXTRACTION FROM SUPERSITE RADAR DATA)

- O BACKGROUND

  MULTIBAND, MULTIANGLE, MULTIPOLARIZATION RADAR SCATTEROMETER DATA WERE ACQUIRED OVER SUPERSITES (WEBSTER, IOWA, CORN AND SOYBEANS -- CASS, NORTH DAKOTA, SMALL GRAINS) ON TWO DATES IN EACH SITE IN 1980.

- O FY81 ACCOMPLISHMENTS

  ANALYSIS OF 1980 DATA STARTED

  PRELIMINARY RESULTS (CORN AND SOYBEANS ONLY)

  - O SEVERE ROW DIRECTION EFFECTS EXIST FOR LIKE-POLARIZED RADAR DATA TAKEN NEAR NADIR (5-25 DEGREES) FOR CORN AND SOYBEAN FIELDS (PRESENTS PROBLEM FOR SOIL MOISTURE SENSING BY RADAR)

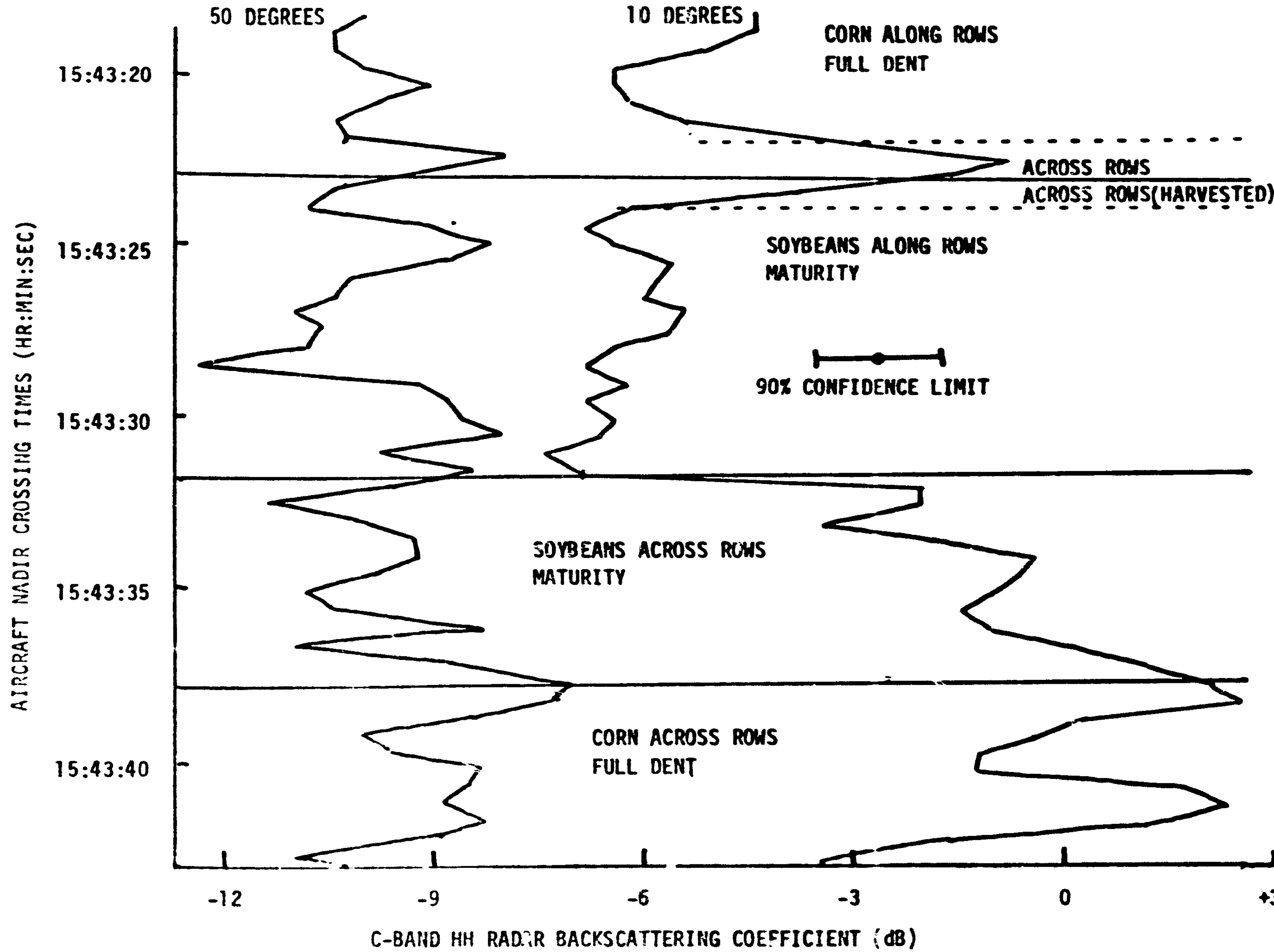
  - O NO SIGNIFICANT ROW DIRECTION EFFECTS EXIST FOR CROSS-POLARIZED DATA (AT ANY ANGLE) OR FOR LIKE-POLARIZED DATA FOR ANGLES GREATER THAN 25 DEGREES

  - O SEPARATION IN RADAR BACKSCATTERING WAS OBSERVED ONLY WITH FOLLOWING SENSOR CONFIGURATIONS (CORN VERSUS SOYBEANS):

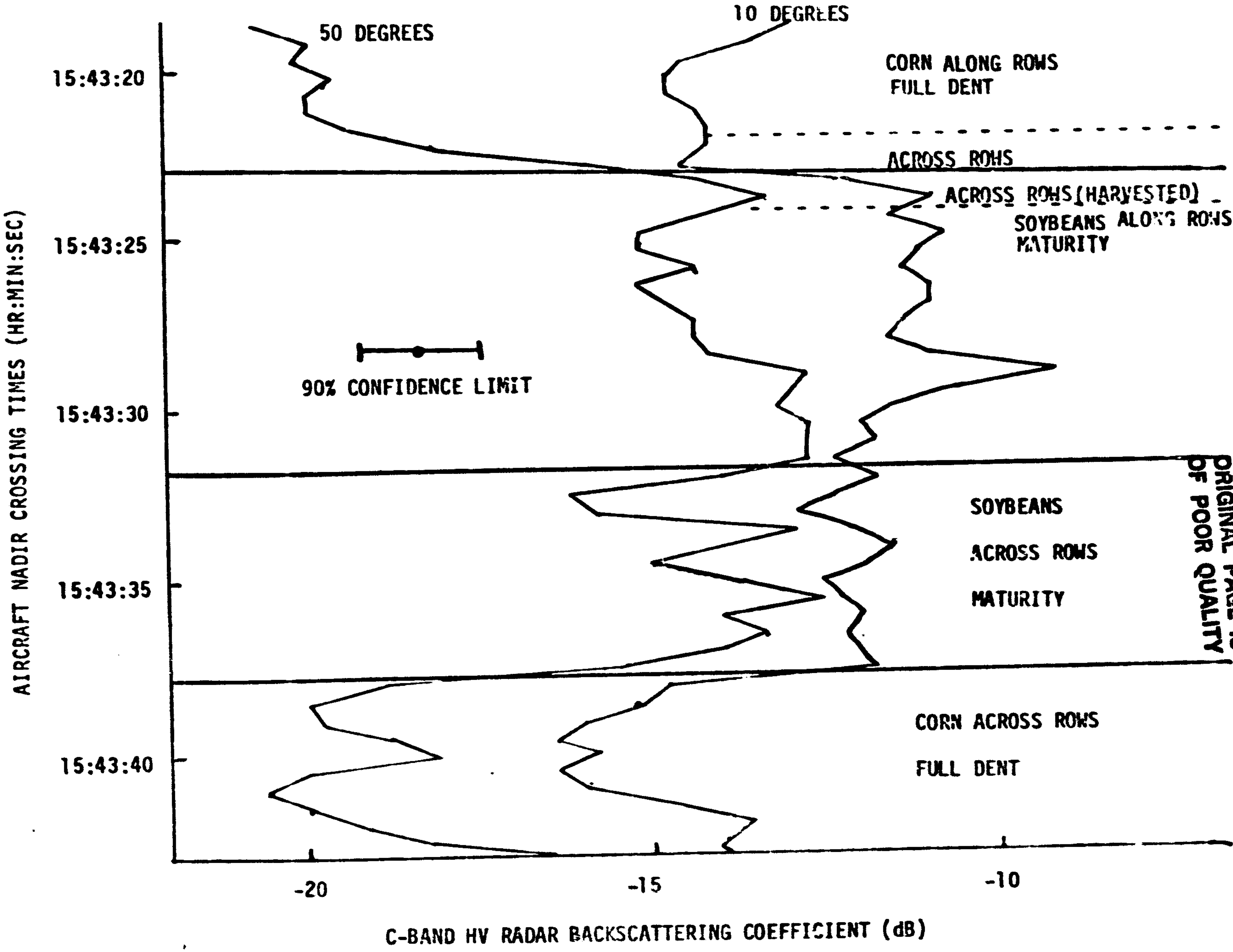
    - \+ C-BAND HV NEAR [illegible] DEGREES VIEWING ANGLE
    - \+ KU-BAND VV NEAR 50 DEGREES VIEWING ANGLE (VH DATA WAS NOT ACQUIRED)

  RADAR DATA WERE ACQUIRED OVER CASS SITE (SMALL GRAINS) ON FOUR DATES SPREAD OUT IN THE GROWING SEASON IN 1981.

WEBSTER COUNTY, IOWA, SUPERSITE DATA FROM 9-10-80



WEBSTER COUNTY, IOWA, SUPERSITE DATA FROM 9-10-80



RADAR EQUATION: $\sigma^{\circ} = \dfrac{(4\pi)^3 P_r R^4}{P_t \lambda^2 G^2 A}$

WHERE

$P_r$ = POWER RETURNED

$P_t$ = POWER TRANSMITTED

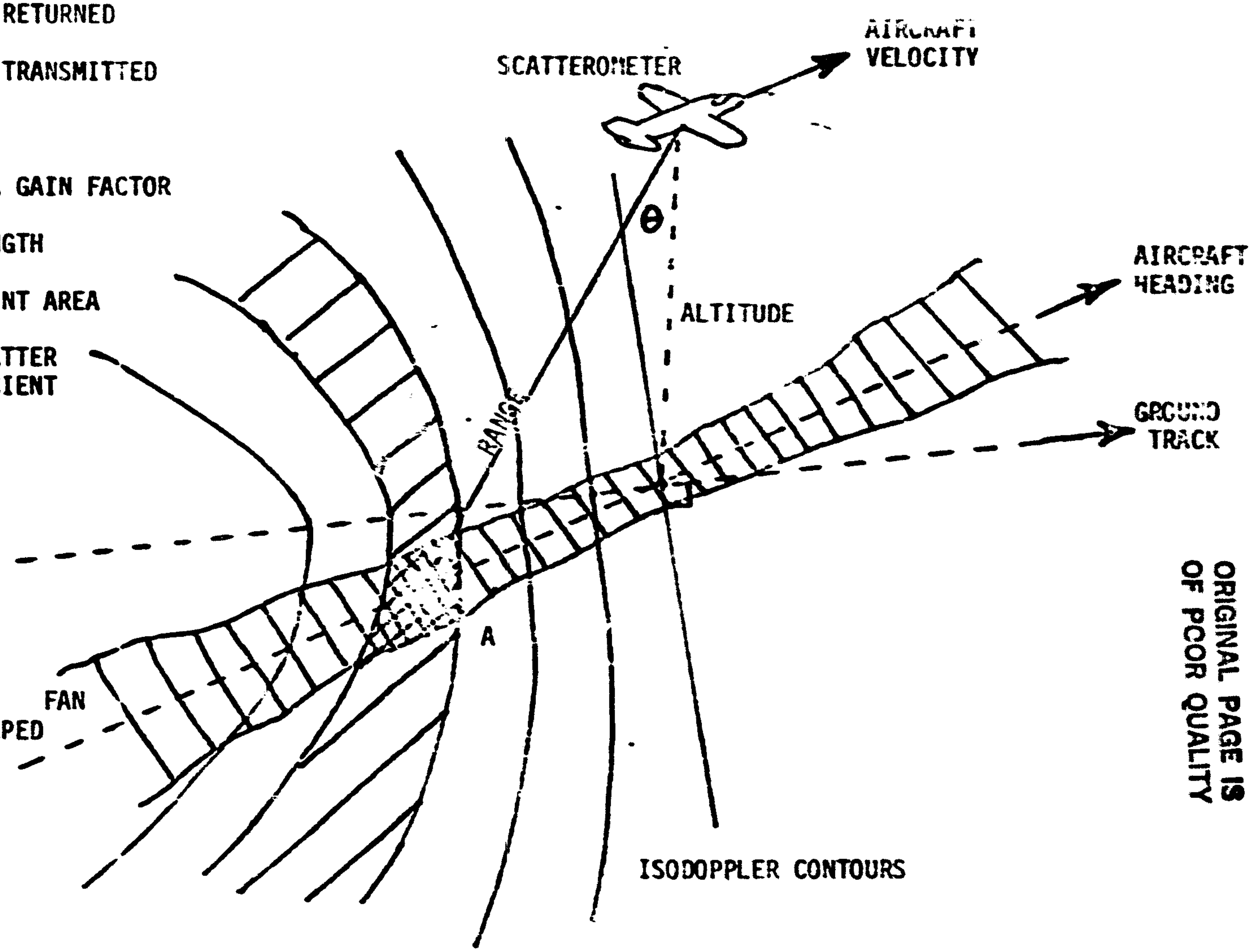
R = RANGE

G = ANTENNA GAIN FACTOR

$\lambda$ = WAVELENGTH

A = FOOTPRINT AREA

$\sigma^{\circ}$ = BACKSCATTER COEFFICIENT




RADAR SCATTEROMETER GEOMETRY AND THE RADAR EQUATION

AGRISTARS SEMIANNUAL REVIEW

OF

SUPPORTING RESEARCH

PATTERN RECOGNITION RESEARCH

11/3/81

## SR PATTERN RECOGNITION PLAN

o THE PATTERN RECOGNITION RESEARCH IS ATTEMPTING TO:

+ DEVELOP AT HARVEST CROP SPECIFIC ACREAGE ESTIMATION METHODS THAT REQUIRE LITTLE OR NO ANALYST INTERVENTION

+ DEVELOP EARLY SEASON ESTIMATION METHODS FOR AT LEAST MAJOR GROUPS OF CROP CLASSES (E.G., SMALL GRAINS)

o TO MEET THESE TWO OBJECTIVES IT WAS DECIDED:

+ TO STUDY DIRECT PROPORTION ESTIMATORS AS OPPOSED TO ESTIMATORS WHICH DEPEND UPON THE CLASSIFICATION OF PIXELS

  -- DIRECT PROPORTION ESTIMATION METHODS ARE THEORETICALLY UNBIASED WHEREAS CLASSIFICATION DERIVED ESTIMATES ARE BIASED.

+ NOT TO DEPEND UPON ANALYST PIXEL LABELING BUT RATHER TO DIRECTLY USE CROP CALENDAR MODEL OUTPUTS TO EFFECT THE LABELING.

+ TO DEVELOP A THEORY THAT WOULD COMBINE THE ANCILLARY AND THE LANDSAT DATA IN MAKING ESTIMATES.

o TO ACCOMPLISH THESE OBJECTIVES IT WAS RECOGNIZED THAT A GREATER EMPHASIS ON THE DEVELOPMENT OF "PHYSICAL" MODELS WAS NEEDED.

+ MODELS THAT CAN TRANSFORM LANDSAT OBSERVATIONS TO "GROWTH" VARIABLES THAT ARE NOT SENSITIVE TO "NOISE" EFFECTS (E.G., RANDOM PLANTING DATE DIFFERENCES, BACKGROUND SOIL COLOR, HAZE, ETC.)

+ MODELS THAT DESCRIBE PLANTING DATE DISTRIBUTIONS AND DISTRIBUTIONS OF CROP CALENDAR EVENTS.

## SR PATTERN RECOGNITION PLAN (CONTINUED)

- O THIS SUMMER THE APPROACH THAT INTEGRATES THE SCENE RADIATION MODELING STUDIES WITH THE PATTERN RECOGNITION ACREAGE ESTIMATION STUDIES WAS DETAILED IN A TECHNICAL RESEARCH PLAN.

- O STATISTICAL ISSUES RELATED TO SAMPLING WERE ALSO ADDRESSED IN THIS PLAN.

  - + AN ATTEMPT WAS MADE TO FOCUS MANY ONGOING STUDIES TO DEFINE A "LARGE AREA" ESTIMATION APPROACH.

- O THE PLAN HAS PINPOINTED SOME WEAKNESSES WHERE A GOOD TECHNICAL APPROACH HAS YET TO BE DEFINED.

  - + AS YET NO CLEARLY DEFINED APPROACH HAS BEEN DEVELOPED TO TREAT "MIXED PIXELS."

  - + WHILE SEVERAL ELEMENTS OF AN APPROACH FOR ESTIMATING CROP ACREAGE EARLY IN THE GROWING SEASON WERE DEFINED, THE DEFINITION OF THE OVERALL APPROACH IS STILL BEING WORKED ON.

# RESEARCH TOPICS

| OBJECTIVES | STUDIES | ISSUES |
| --- | --- | --- |
| O DEVELOP IMPROVED SEGMENT LEVEL ESTIMATORS (SMALL GRAINS CONSORTIUM) | O DIRECT PROPORTION ESTIMATORS<br>O FEATURE ESTIMATION AND EVALUATION<br>O SPATIAL PROCESSING TO ISOLATE PURE AND MIXED PIXELS<br>O ESTIMATORS FOR MIXED PIXEL AREAS | O SPECTRAL CONFUSION BETWEEN CROP TYPES HAS LEAD TO BIASED ESTIMATES IN PAST STUDIES.<br>O MIXED PIXELS ARE MAJOR CONTRIBUTORS TO BIAS AND VARIANCE OF SEGMENT ESTIMATES<br>O MANUAL LABELING CAN BE A MAJOR SOURCE OF BIAS OF A SEGMENT ESTIMATE. |
| O COMBINE SEGMENT AREA ESTIMATION CONCEPTS WITH SAMPLING DESIGN CONCEPTS TO DEVELOP HIGH PRECISION LARGE AREA ESTIMATORS (CORN/SOYBEAN & MATH/STAT CONSORTIUM) | O DYNAMIC STRATIFICATION<br>O SELECTION OF SAMPLING UNITS<br>O AGGREGATION | O PROPER USE OF CORRELATED DATA CAN LEAD TO EFFICIENT (LOW VARIANCE) ESTIMATES<br>O MANUAL LABELING IS A TIME CONSUMING (COSTLY) PROCESS. |

RESEARCH TOPICS (CONT.)

| OBJECTIVES | STUDIES | ISSUES |
|---|---|---|
| O DEVELOP ESTIMATION METHODS THAT CAN BE APPLIED EARLY IN THE CROP GROWING SEASON (SMALL GRAINS & CORN/SOYBEANS CONSORTIUMS) | O AG-ECONOMETRIC MODELS<br>O USE OF EARLY IN-SEASON LANDSAT DATA<br>O MULTIYEAR ESTIMATORS<br>O THROUGH-THE-SEASON ESTIMATION APPROACH | O DATA FOR OBSERVING CROP GROWTH CHARACTERISTICS ARE MINIMAL EARLY IN THE SEASON<br>O FACTORS WHICH INFLUENCE PLANTING INTENTIONS CANNOT BE ENTIRELY DERIVED FROM LANDSAT OR WEATHER DATA. |
| O DEVELOP AN AUTOMATIC REGISTRATION CAPABILITY FOR REGISTERING TO SUBPIXEL ACCURACY (REGISTRATION CONSORTIUM) | O IMPROVE UPON THE JSC (LIVES) LANDSAT-LANDSAT REGISTRATION CAPABILITY<br>O REGISTRATION OF TM DATA<br>O REGISTRATION OF AIRCRAFT DATA | O MISREGISTRATION IS A MAJOR FACTOR IN THE USE OF MULTITEMPORAL DATA TO OBTAIN CROP PROPORTION ESTIMATES. |

## SAMPLING ISSUES

O SAMPLING APPROACHES THAT MAKE EFFECTIVE USE OF REMOTELY SENSED DATA (LANDSAT) TO ESTIMATE CROP ACREAGE SHOULD CONSIDER:

++ UNBIASED ALLOCATION AND ESTIMATION METHODS THAT GIVE LOW VARIANCE ESTIMATES WITH FEW SAMPLES.

++ PROVIDE A SUFFICIENT AMOUNT OF DATA TO ESTIMATE THE "SPECTRAL SIGNATURES" USED BY CLASSIFIERS OR DIRECT PROPORTION ESTIMATION METHODS

O THE TECHNICAL RESEARCH PLAN DIVIDES THE SAMPLING ISSUES INTO THREE GROUPS

<u>STRATIFICATION</u>

ISSUE: --VARIABLE CHARACTERISTICS OF ELEMENTS SUCH AS CROP GROWTH, THE ATMOSPHERE, AND CROPPING PRACTICES CAUSE SPECTRAL SIGNATURES TO VARY ACROSS AN IMAGE.

--STATIC CHARACTERISTICS SUCH AS SOIL TYPE, TERRAIN, AND CLIMATE EFFECT SIGNATURES AND THE TYPE AND PERCENTAGES OF CROPS GROWN IN AN AREA.

APPROACH: --DEVELOP STRATA BASED ON THESE NATURAL STATIC EFFECTS.

--REFINE THE STATIC STRATA WITH DYNAMIC STRATA BASED ON CROP CALENDAR PREDICTIONS AND SPECTRAL CLUSTERING METHODS.

# SAMPLING ISSUES (CONTINUED)

SAMPLING UNITS

ISSUE: --LARGE NUMBER OF SMALL UNITS RATHER THAN A SMALL NUMBER OF LARGE UNITS OFFERS BETTER SAMPLING EFFICIENCY.

--TOO SMALL A SAMPLING UNIT WILL NOT PROVIDE ENOUGH SPECTRAL SAMPLES TO ESTIMATE "LOCALLY STABLE" SIGNATURES.

APPROACH: --CONSIDER AN "OPTIMUM" SIZE UNIT OR ALLOCATE TWO SAMPLING UNIT SIZES; ONE SIZE TO ESTIMATE ACREAGE AND ANOTHER TO "TRAIN" THE ESTIMATOR.

--DYNAMIC STRATA WOULD BE USED FOR ALLOCATING TRAINING SAMPLES STATIC STRATA USED FOR ALLOCATING THE SMALLER UNITS FOR ACREAGE ESTIMATION.

AGGREGATION

ISSUE: --MISSING SEGMENT ESTIMATES AND MISSING ACQUISITIONS INTRODUCE ESTIMATION ERRORS.

--DESIRABLE TO COMBINE ESTIMATION METHODS WHICH HAVE DIFFERENT PRECISION AND/OR "COSTS."

APPROACH: --POSSIBLE ESTIMATORS THAT WILL BE STUDIED ARE:

+ REGRESSION-AGGREGATION METHODS
+ MULTIYEAR ANOVA ESTIMATOR
+ WEIGHTED AGGREGATION
+ PARTIAL RESPONSE MODELS

O AN INITIAL SET OF STUDIES ARE PLANNED WHICH WOULD USE THE PROFILE CLASSIFIER AS A "LOW COST" ESTIMATOR.

## OVERVIEW OF MAJOR STUDY RESULTS

- O AN APPROACH FOR ESTIMATING CORN AND SOYBEANS ACREAGE IN A SEGMENT HAS BEEN EVALUATED, DOCUMENTED, AND DELIVERED TO FCPF. THIS APPROACH IS AN OUTGROWTH OF OUR PROFILE ANALYSIS STUDIES.

- O IN THE LAST REVIEW A PROPORTION ESTIMATION APPROACH FOR ESTIMATING CROP ACREAGES OF SMALL GRAINS CROPS WAS DEFINED AND CALLED PROCEDURE 1A--NOW IT IS CALLED APEP (ADVANCED PROPORTION ESTIMATION PROCEDURE).

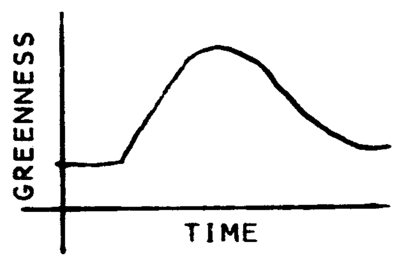
  - \+ AN EVALUATION OF AN APPROACH FOR ESTIMATING THE NUMBER OF SPECTRAL CROP CLASSES IN APEP HAS BEEN COMPLETED.

  - \+ STUDIES ARE BEGINNING TO SHOW THAT CERTAIN COMBINATIONS OF VARIABLES DERIVED FROM PROFIELS DISPLAY PROBABILITY DISTRIBUTIONS THAT EXHIBIT GOOD CROP "SPECTRAL SEPARATION" AND CAN BE MODELED.

- O A CLASS OF AG-ECONOMETRIC MODELS HAVE BEEN EVALUATED ON SUMMER CROPS IN MISSOURI. THESE STUDIES ARE AIMED AT UNDERSTANDING HOW "PRIOR INFORMATION" IS DERIVED FROM ANCILLARY DATA AND PREVIOUS YEAR LANDSAT-DERIVED ESTIMATES COULD BE USED FOR EARLY SEASON ACREAGE ESTIMATION.

## CORN/SOYBEANS PROFILE CLASSIFIER

- THE STUDY OF TEMPORAL PROFILES OF CORN AND SOYBEANS HAS SHOWN THAT THE PARAMETERS $(\alpha, \beta)$ ARE GOOD STABLE VARIABLES FOR DISTINGUISHING AMONG CORN, SOYBEANS, AND "OTHER."
  - --RECAL THAT GREENNESS VS TIME (CALLED A PROFILE) IS MODELED AS A SIGMOIDAL FUNCTION




MODEL: $A(t/t_o)^{\alpha} e^{1/2\beta(t_o^2 - t^2)}$

- TO OBTAIN A BETTER UNDERSTANDING OF APPROACHES THAT WOULD USE PROFILE PARAMETERS AS FEATURE VARIABLES, A CLASSIFICATION SYSTEM WAS DESIGNED, EVALUATED IN EXPLORATORY EXPERIMENTS, DOCUMENTED, AND DELIVERED TO FCPF FOR LARGER SCALE STUDIES.

- FEATURES OF THE APPROACH ARE:
  - --GROWTH VARIABLES DERIVED FROM A PROFILE MODEL ARE USED AS THE FEATURE VARIABLES.
  - --A BOUNDARY FINDING ALGORITHM IS USED TO AUTOMATICALLY SINGLE OUT PURE PIXELS.
  - --AN ANALYST IS REQUIRED TO LABEL 20 <u>PURE</u> DOTS PER CLASS (CORN, SOYBEANS, OTHER) TO TRAIN A CLASSIFIER.
  - --ALL PIXELS (PURE AND MIXED) ARE CLASSIFIED BY A LINEAR CLASSIFIER AND THE CORN AND SOYBEAN ACREAGES ARE ESTIMATED BY COUNTING THE CLASSIFIED PIXELS.

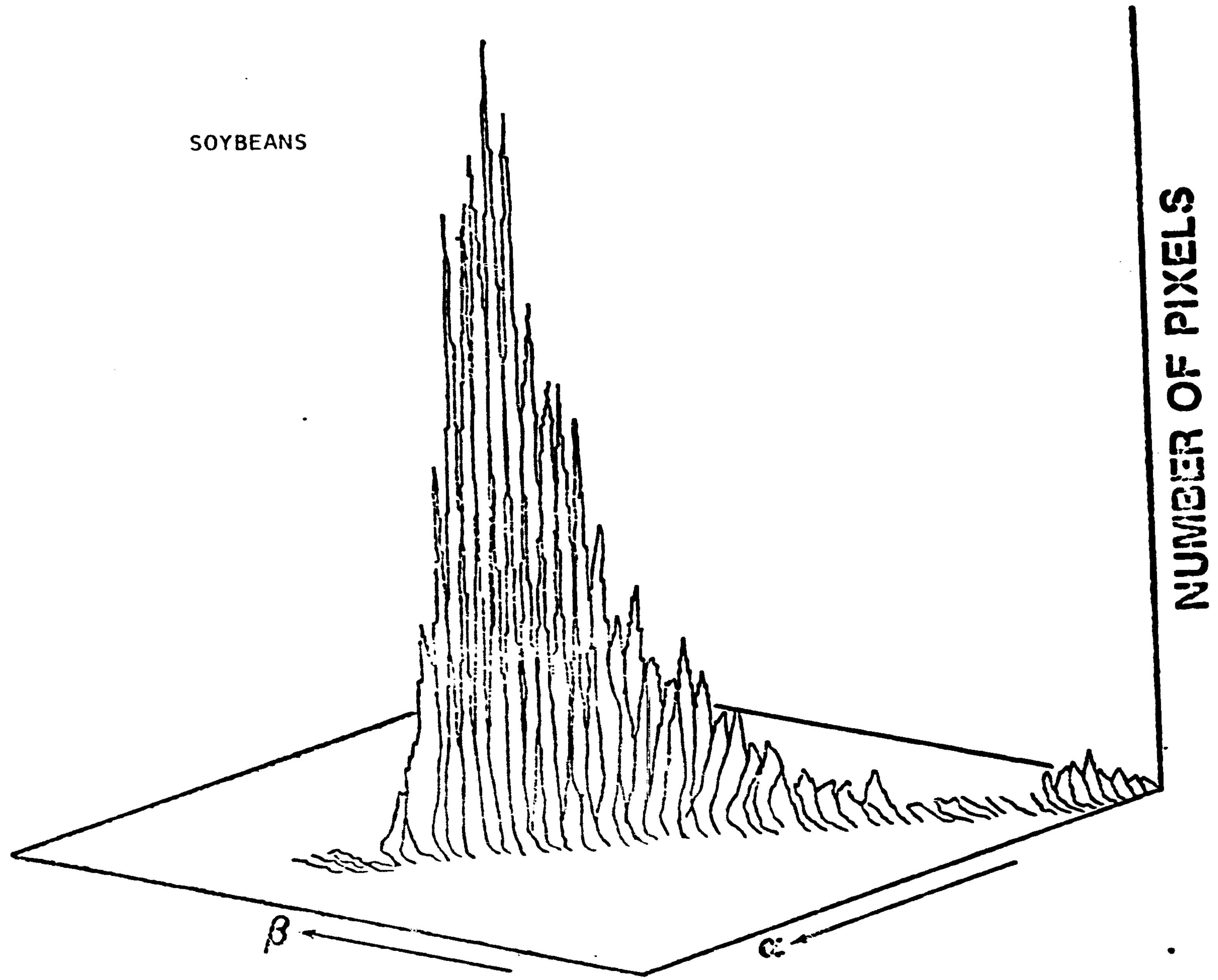





Fig.

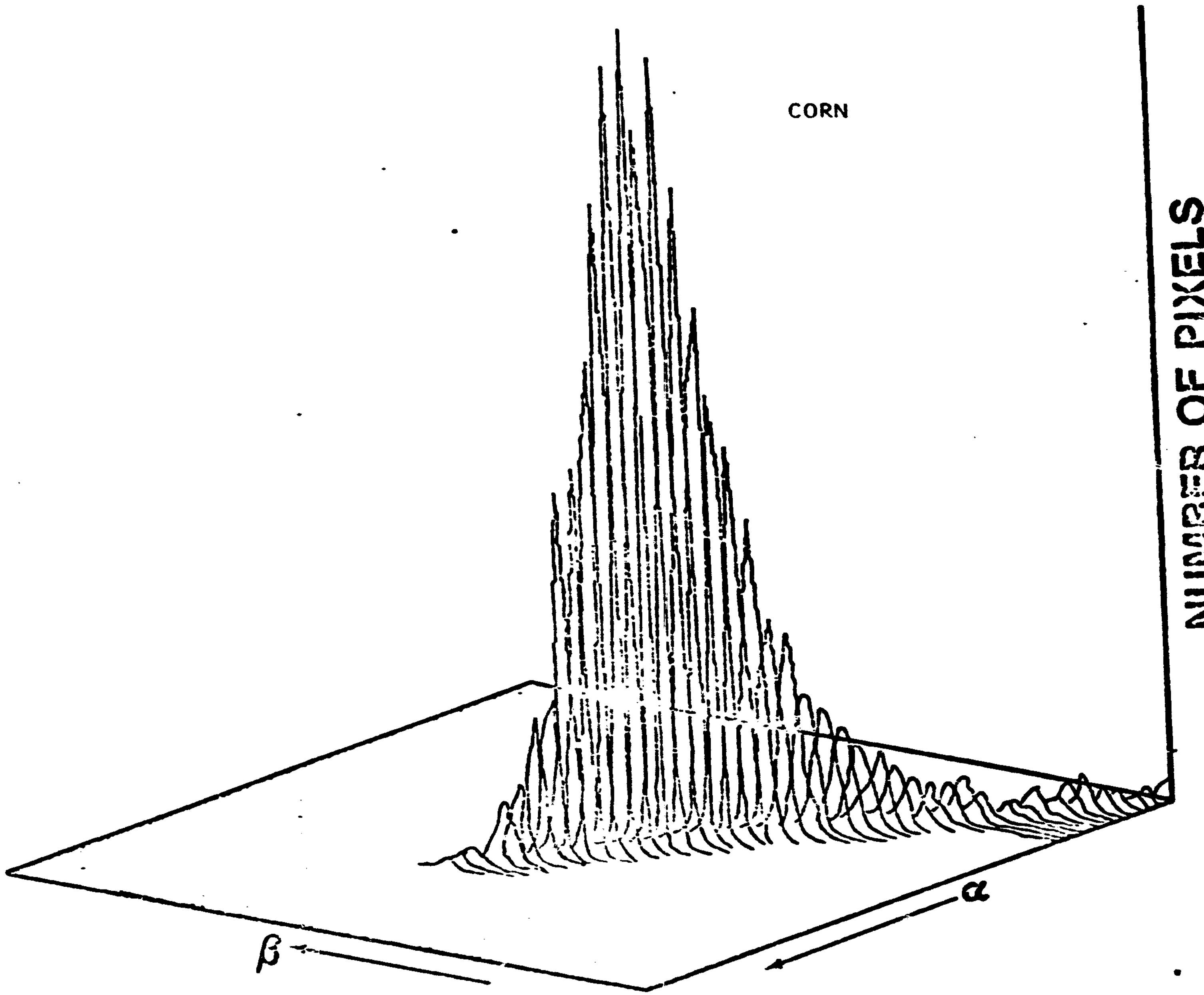



Fig. 7a

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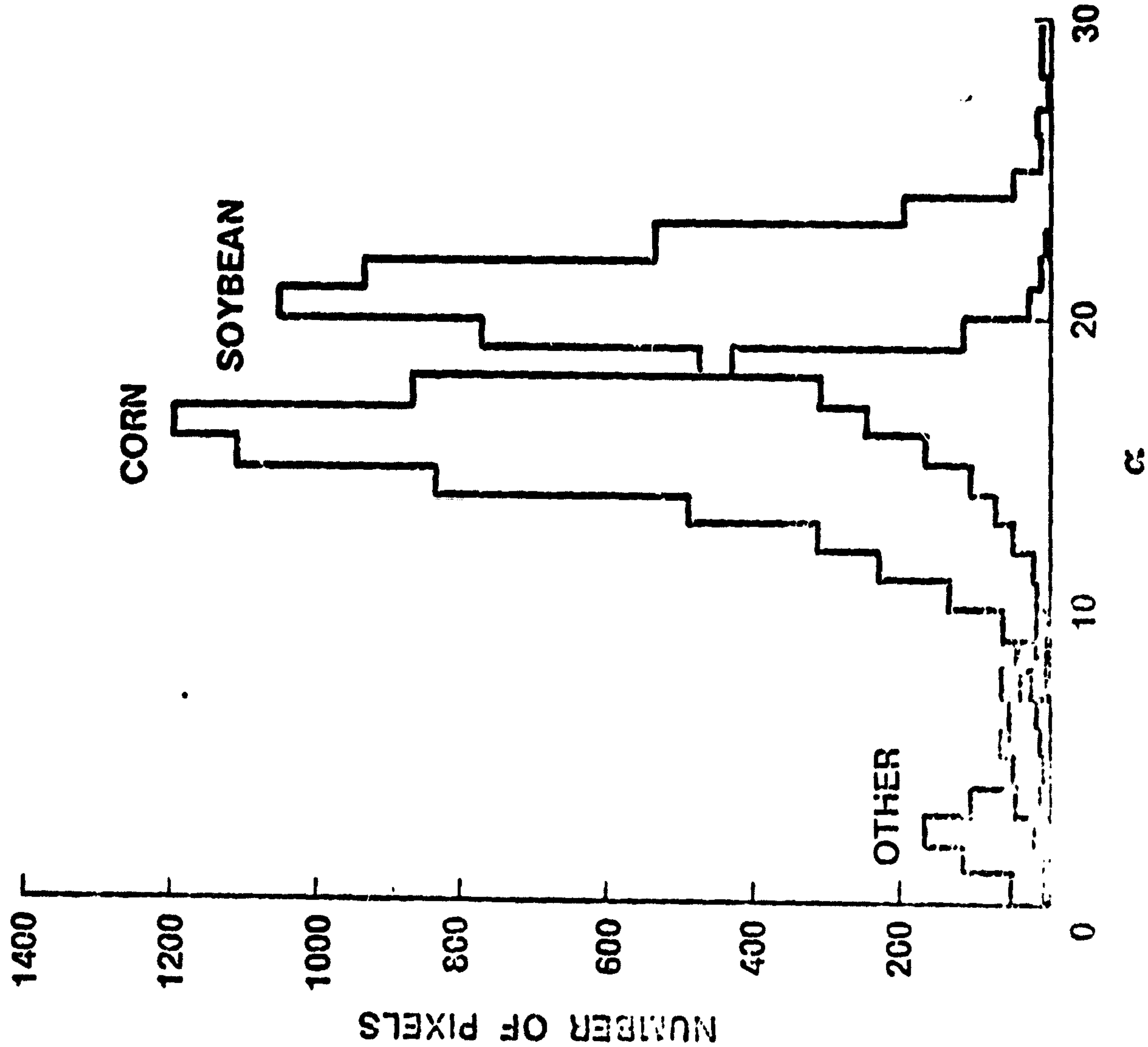
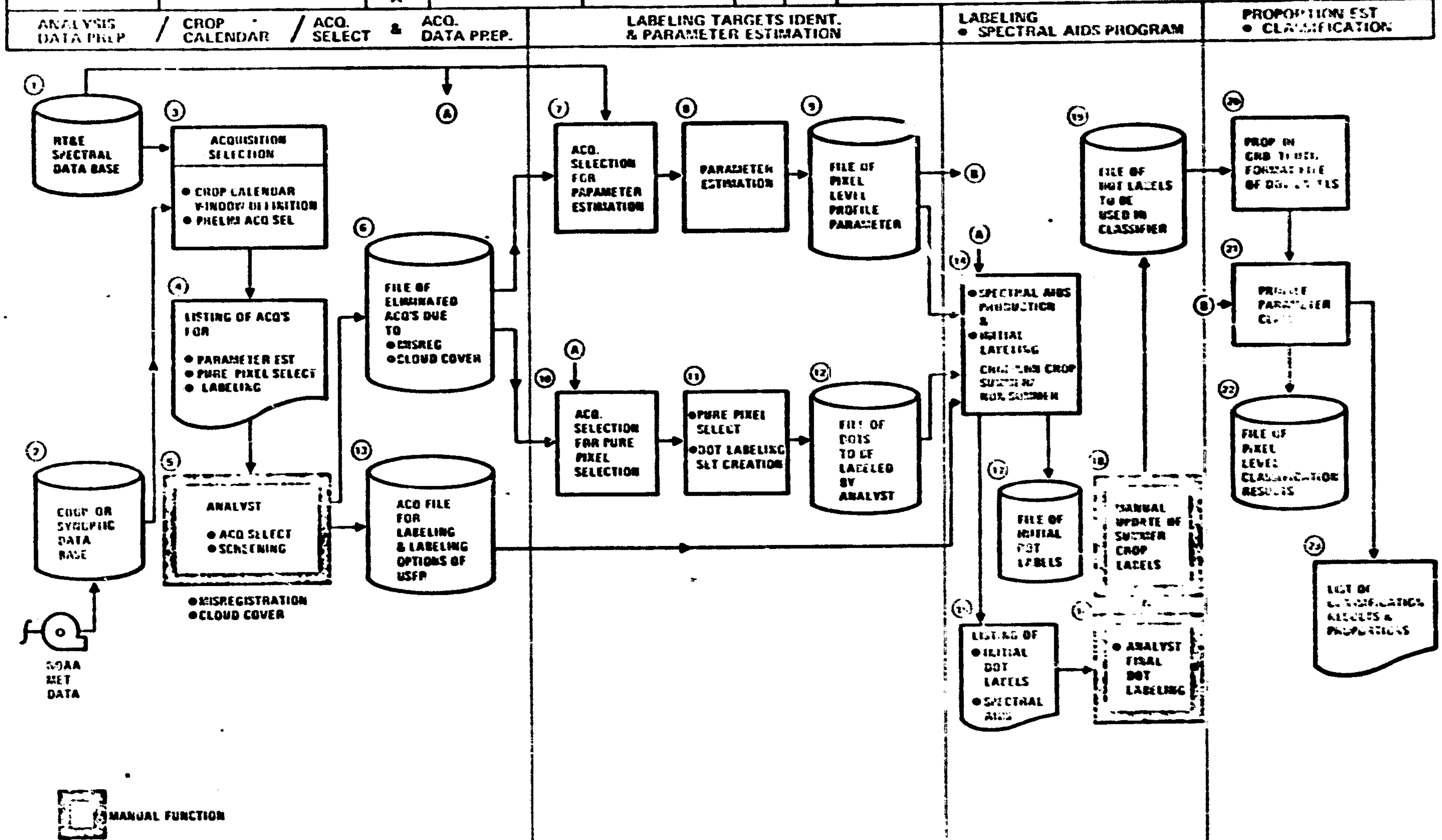


| LEVEL | TYPE | CODE | REGION | CROP PROC. | NO. | VAR | PROCEDURE NAME | DATE |
|---|---|---|---|---|---|---|---|---|
| SUBSYSTEM | AREA ESTIMATION | A | U. S. CORN BELT | C/S | | 4 | PROFILE PARAMETER CLASSIFICATION | 7/27/81 |

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OF POOR QUALITY

| LEVEL | TYPE | CODE | REGION | CROP PROC. | NO. | VAR. | PROCEDURE NAME | DATE |
|---|---|---|---|---|---|---|---|---|
| SUBSYSTEM | AREA ESTIMATION | | CORN U.S. BELT | C/S | | 4 | PROFILE PARAMETER CLASSIFICATION | |

## FUNCTION DESCRIPTIONS

1. All Landsat imagery used within any of the Programs is taken from the RT&E data base. Information concerning available acquisition is from the RT&E data base directory.

2. The Coop or Synoptic data base consists of three files generated for the first order weather stations in the U.S. Corn Belt region. There is a file containing the 25% crop stages, 50% crop stages and 75% crop stages for corn and soybeans.

3. Using the synoptic data base the crop calendar is produced for corn and soybean stages. Using the same data, labeling procedure window definitions (center, opening, and closing dates) are computed.

4. Keying on defined crop stages a list of acquisitions are selected as candidates for the following three purposes: parameter estimation and pure pixel determination and labeling.

5. The analyst examines the acquisitions included in the various lists for cloud cover, shadow and misregistration or bad data.

6. The analyst enters a file consisting of all acquisitions he has selected to eliminate.

7. From the list of parameter estimation candidates all acquisitions within the elimination file are deleted. If more than eight acquisitions remain a set of programmed logic steps is processed until there are only eight acquisitions remaining.

8. After application of the above step (7) the parameter estimation program is executed using the chosen acquisitions.

9. The parameter estimation program produces a file of 418 grid pixel level profile parameters or a file containing pixel level profile parameters for the full segment.

10. From the list of Pure Pixel candidates all acquisitions within the elimination file are deleted. If more than eight acquisitions remain a set of programmed logic steps are processed until there are only eight acquisitions remaining.

11. The Pure Pixel selection program is executed using the chosen acquisitions.

12. A file containing the pixel purity and coordinate for 418 grid dots is produced by the pure pixel selection program.

| LEVEL | TYPE | CODE | REGION | CROP PROC. | NO. | VAR. | PROCEDURE NAME | DATE |
|---|---|---|---|---|---|---|---|---|
| SUBSYSTEM | AREA ESTIMATION | | U.S. CORN BELT | C/S | | 4 | PROFILE PARAMETER CLASSIFICATION | |

FUNCTION DESCRIPTIONS

13. Using information from the analyst's report the acquisitions are placed in files for executing the automated portion of labeling selected execution of the various spectral aids and creation of analysis aids (spectral aids and tables).

14. The crop/noncrop and summer/nonsummer programs are executed and the analysts aids are produced for the segment using the selected acquisitions.

15. Output from the spectral aids include the initial dot labels; labeled and unlabeled scatter plots.

16. The analyst reviews the 418 initial dot labels.

17. A disk file of the 418 initial labels is written to the user A disk.

18. The analyst selects from the 418 initial dot labels the final pure labels.

19. The disk file of initial labels is edited to reflect the analyst final labels as "pure" numeric labels.

20. The "pure" numeric codes are used to create a "simulated" pure pixel ground truth file.

21. The Profile Parameter Classification program is executed using as input the file produced by the parameter estimator and the simulated ground truth (training dots).

22. A universal formatted classification file is produced by the profile parameter classifier.

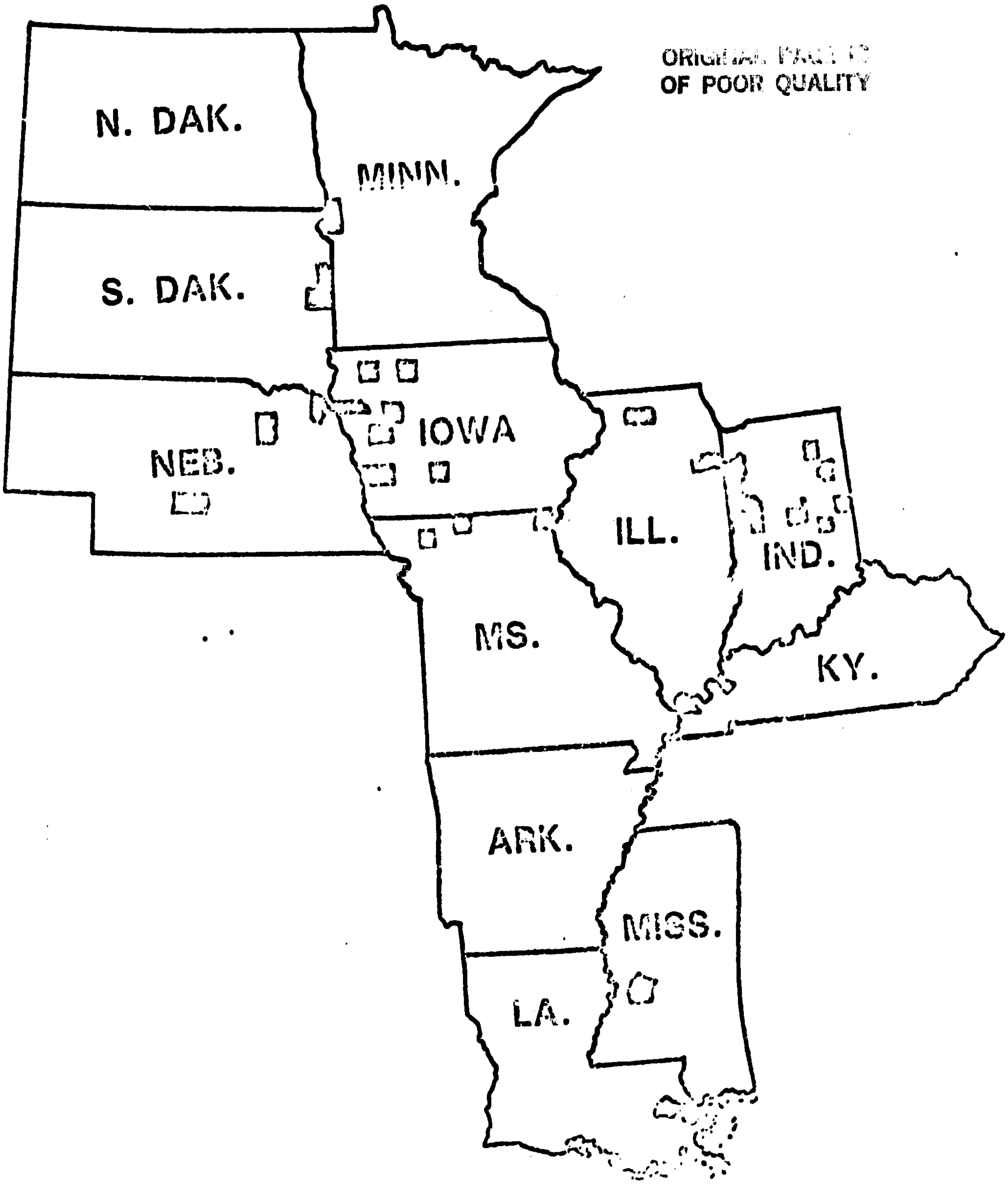
23. A list of classification results, proportions, and map is produced with the execution of the parameter classifier.

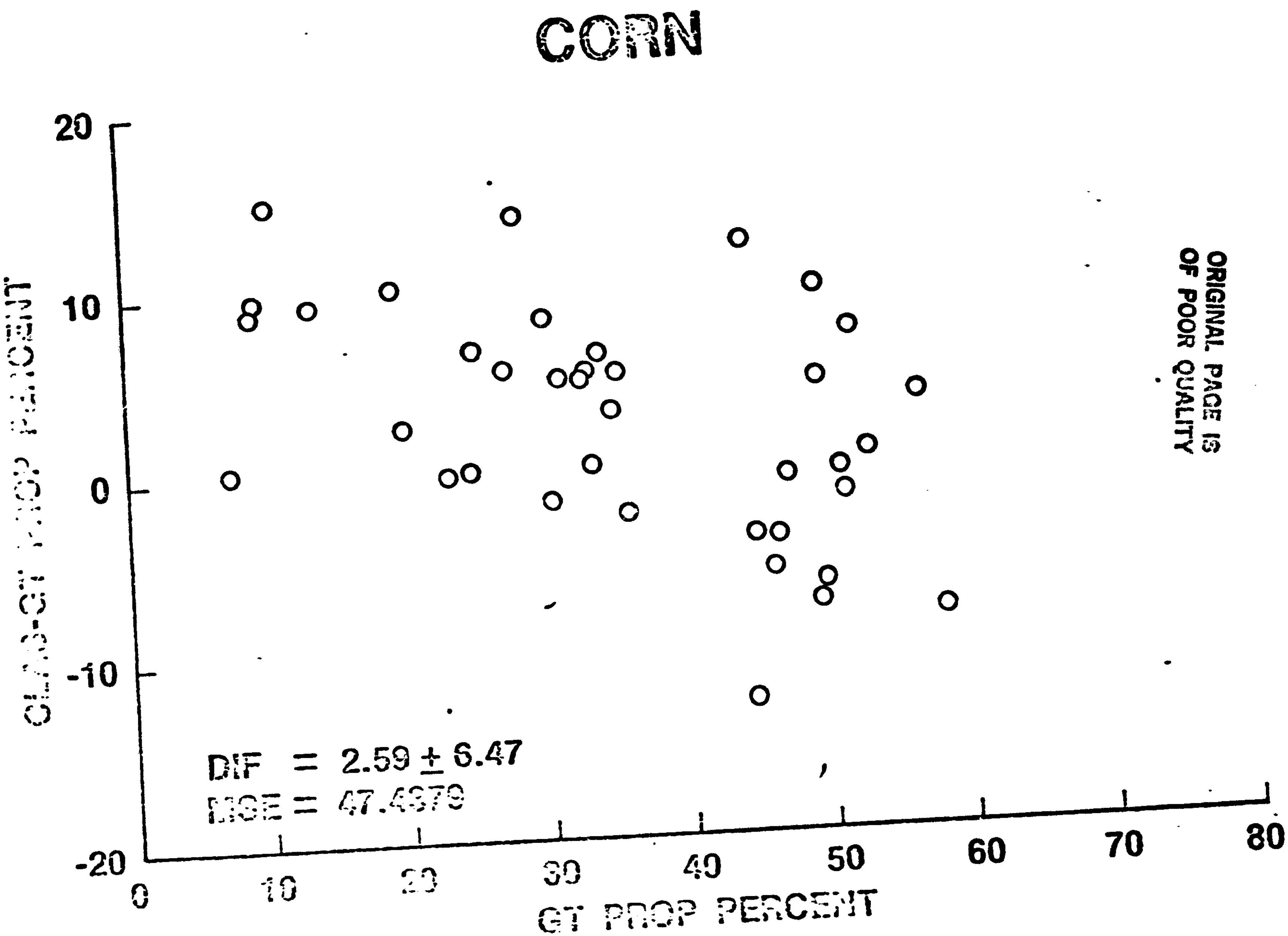
A COMPARISON OF VARIOUS CLASSIFICATION PROCEDURES

| SOURCE OF CLASSIFICATION | CORN | | | SOYBEANS | | |
|---|---|---|---|---|---|---|
| | MEAN ERROR | STANDARD DEVIATION | MEAN SQUARE ERROR | MEAN ERROR | STANDARD DEVIATION | MEAN SQUARE ERROR |
| 100 TYPE 2 ANALYST LABELED DOTS AS RANDOM SAMPLE S* (25 SEGMENTS) | 3.71 | 8.15 | 78.9 | -5.76 | 7.34 | 85.9 |
| 60 GROUND TRUTH DOTS AS RANDOM SAMPLE (40 SEGMENTS) | 0.32 | 4.77 | 22.32 | 0.39 | 4.94 | 23.94 |
| 60 "SUPER PURE" TRAINING DOTS PROFILE PARAMETER (40 SEGMENTS) | 2.59 | 6.47 | 47.44 | -2.30 | 4.38 | 23.92 |
| PROCEDURE M (5 SEGMENTS) | 4.70 | 3.55 | | -3.21 | 3.38 | |

*PROCEDURE P1

# DISTRIBUTION OF CORN SEGMENT DATA SET




CORN
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
DIF = 2.59 ± 6.47
MSE = 47.4379
GT PROP PERCENT
CLASS-GT PROP PERCENT

# SOYBEAN

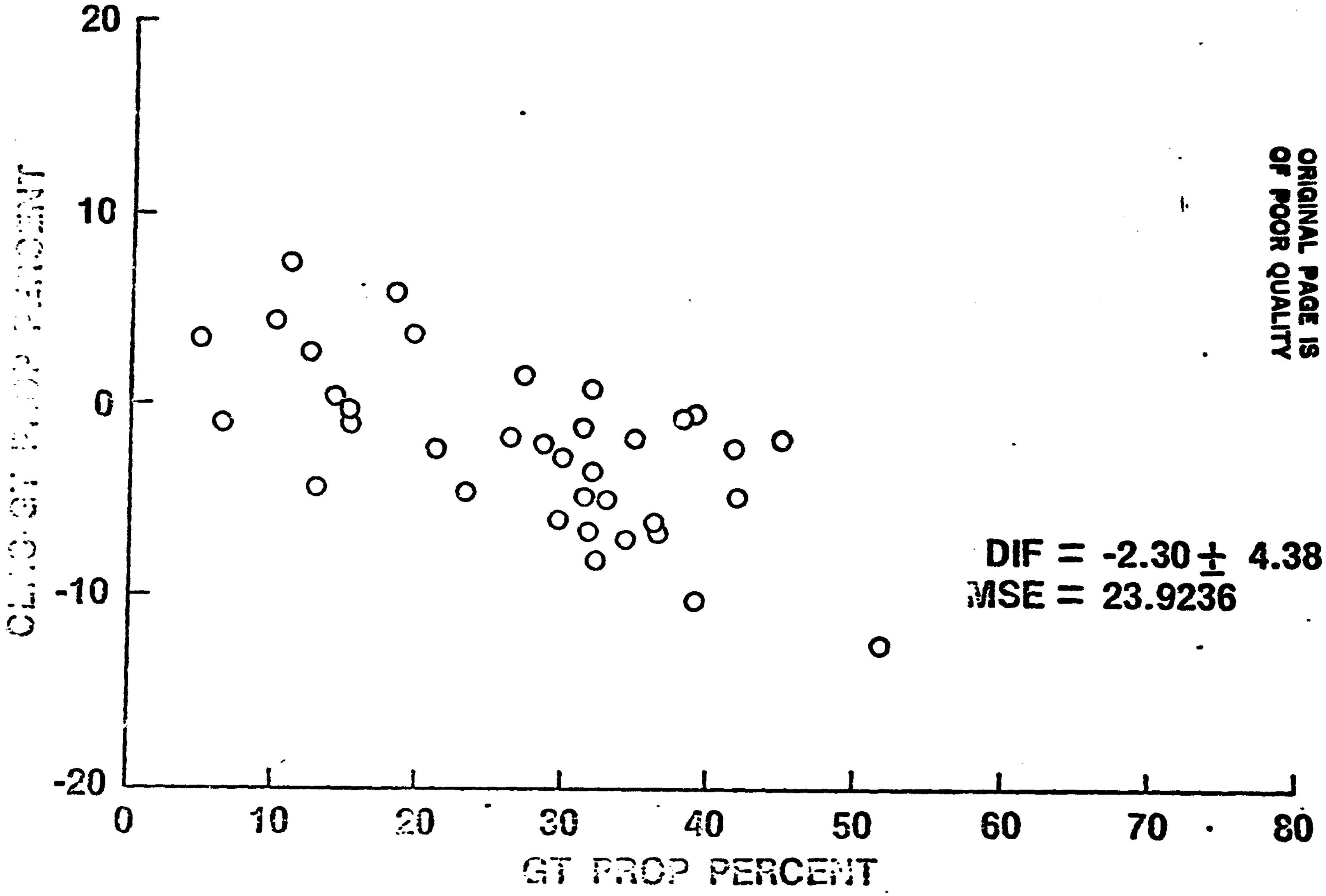
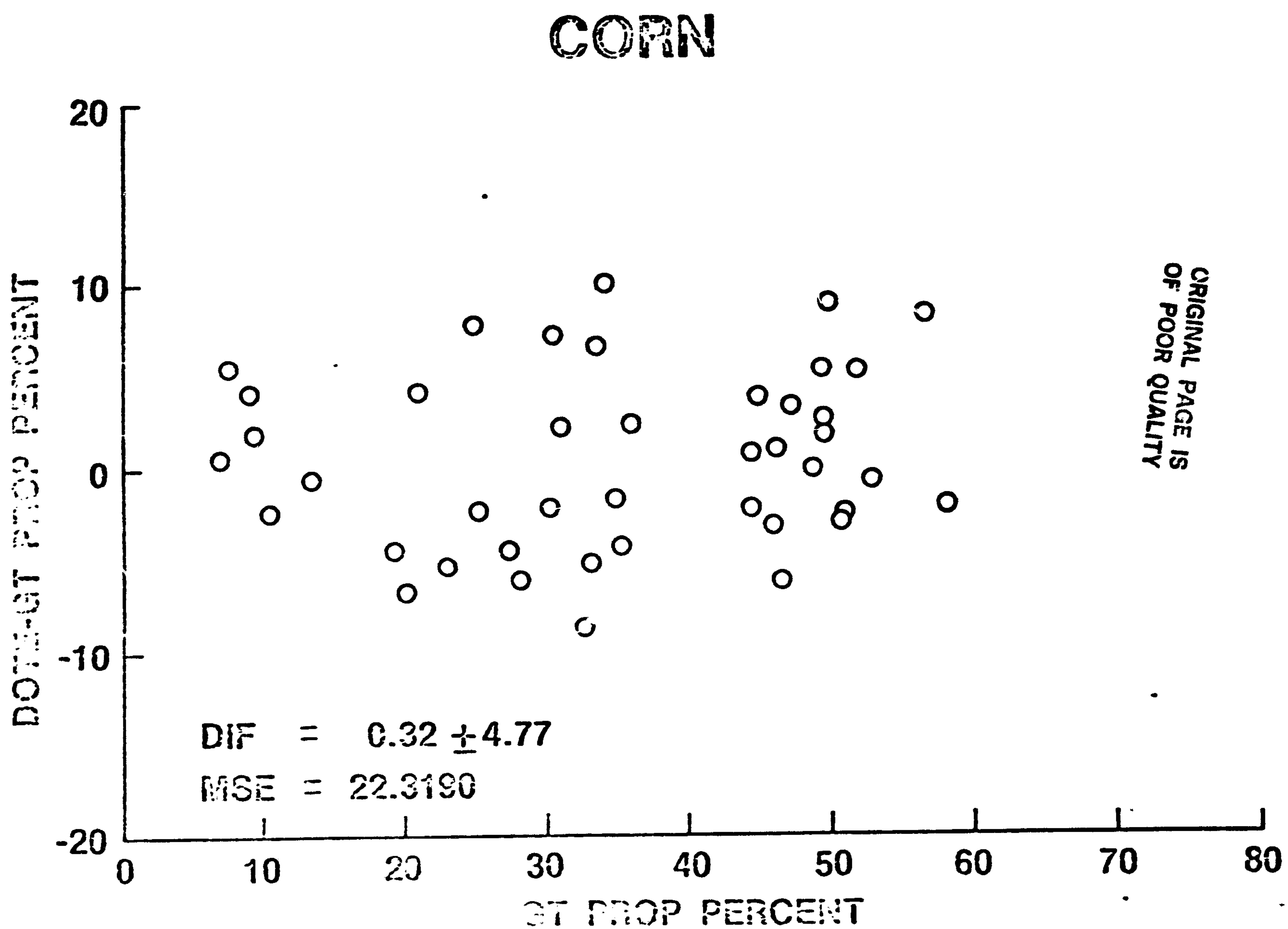

20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
GT PROP PERCENT
DIF = -2.30 ± 4.38
MSE = 23.9236



Fig.


CORN
20
10
0
-10
-20
DOTE-GT PROP PERCENT
DIF = 0.32 ± 4.77
MSE = 22.3190
0
10
20
30
40
50
60
70
80
GT PROP PERCENT

# SOYBEAN

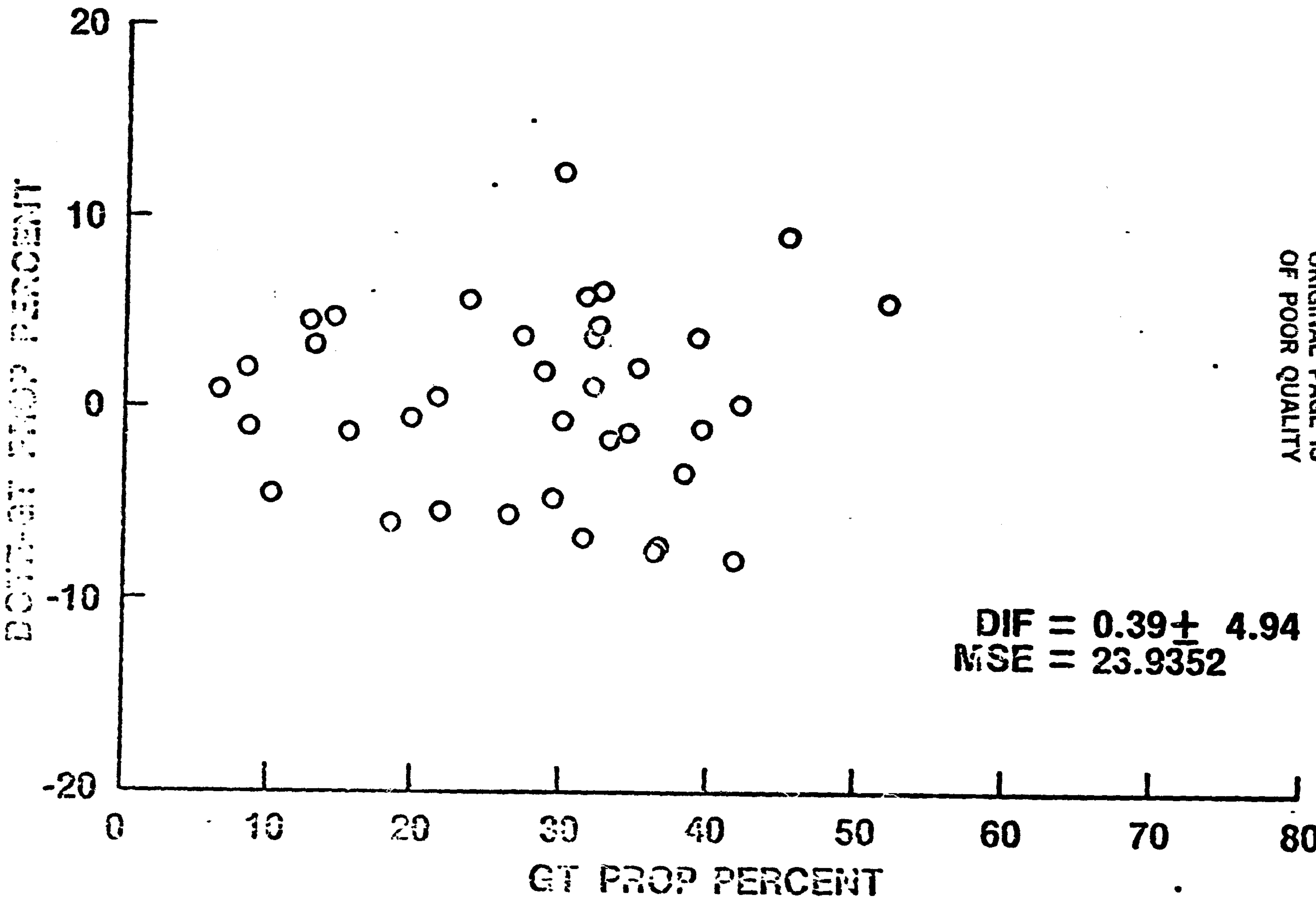
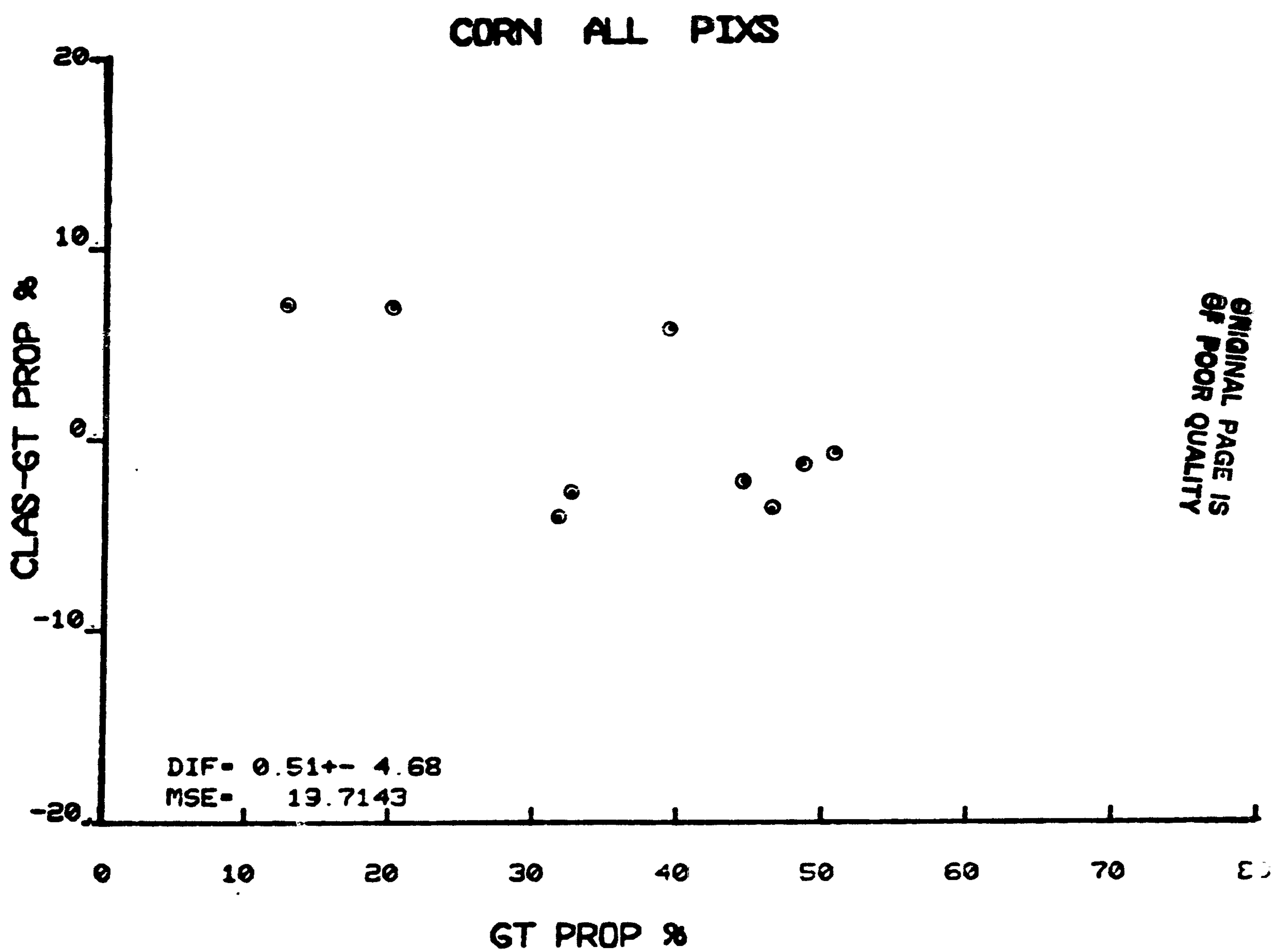
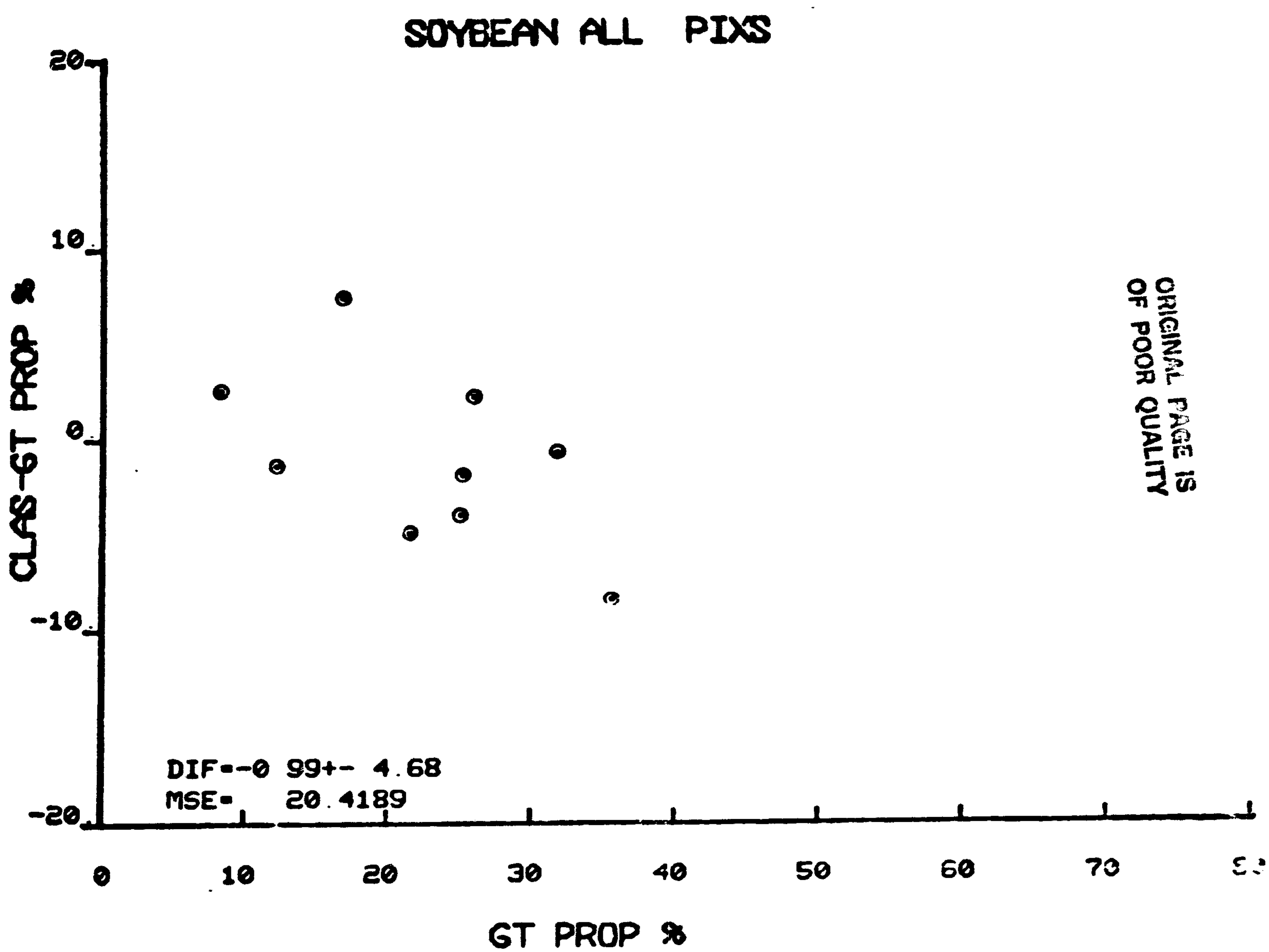




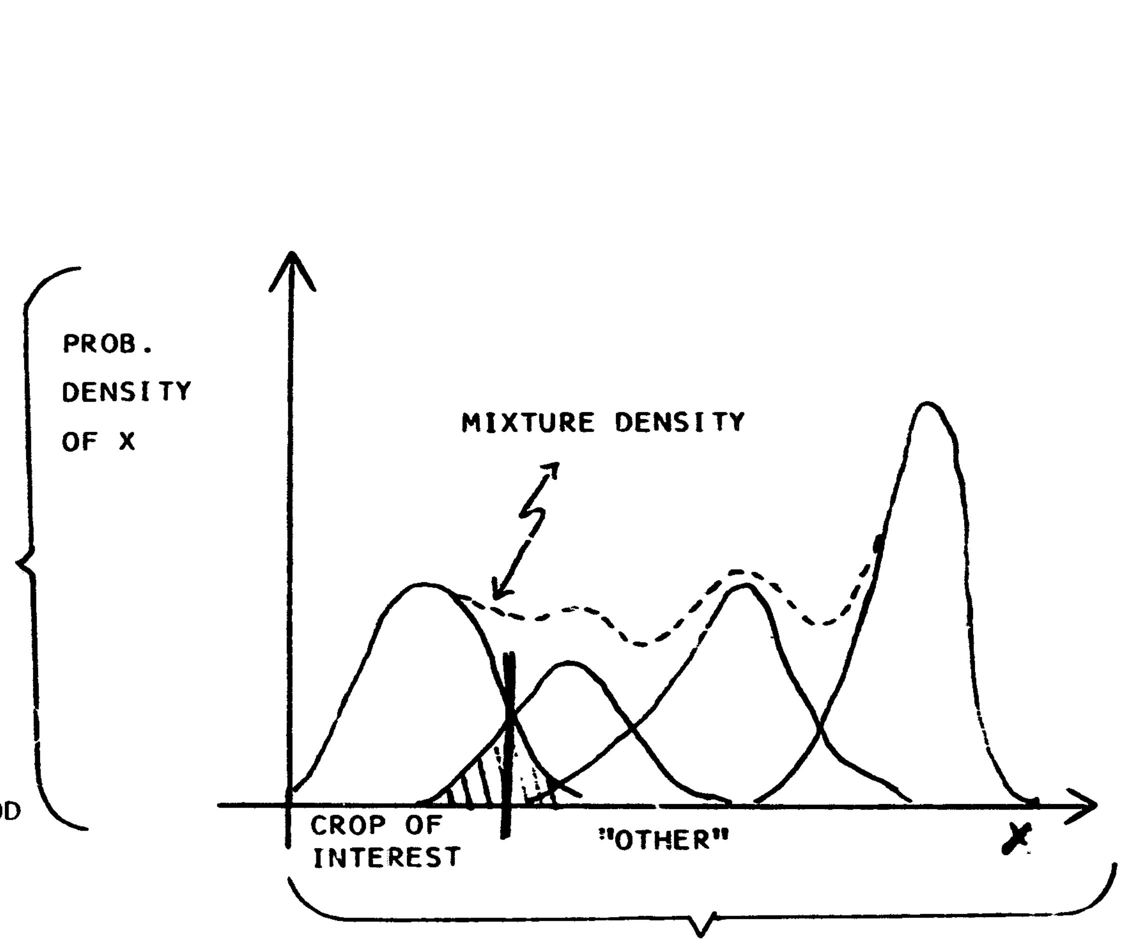

Fig. 113


CORN ALL PIXS
20
10
0
-10
-20
CLAS-GT PROP %
DIF= 0.51+- 4.68
MSE= 13.7143
0
10
20
30
40
50
60
70
GT PROP %


SOYBEAN ALL PIXS
20
10
0
-10
-20
CLAS-GT PROP %
DIF=-0 99+- 4.68
MSE= 20.4189
0
10
20
30
40
50
60
70
GT PROP %

MIXTURE MODEL APPROACH
DIVIDES THE PROBABILITY
DENSITY OF X INTO GROUPS

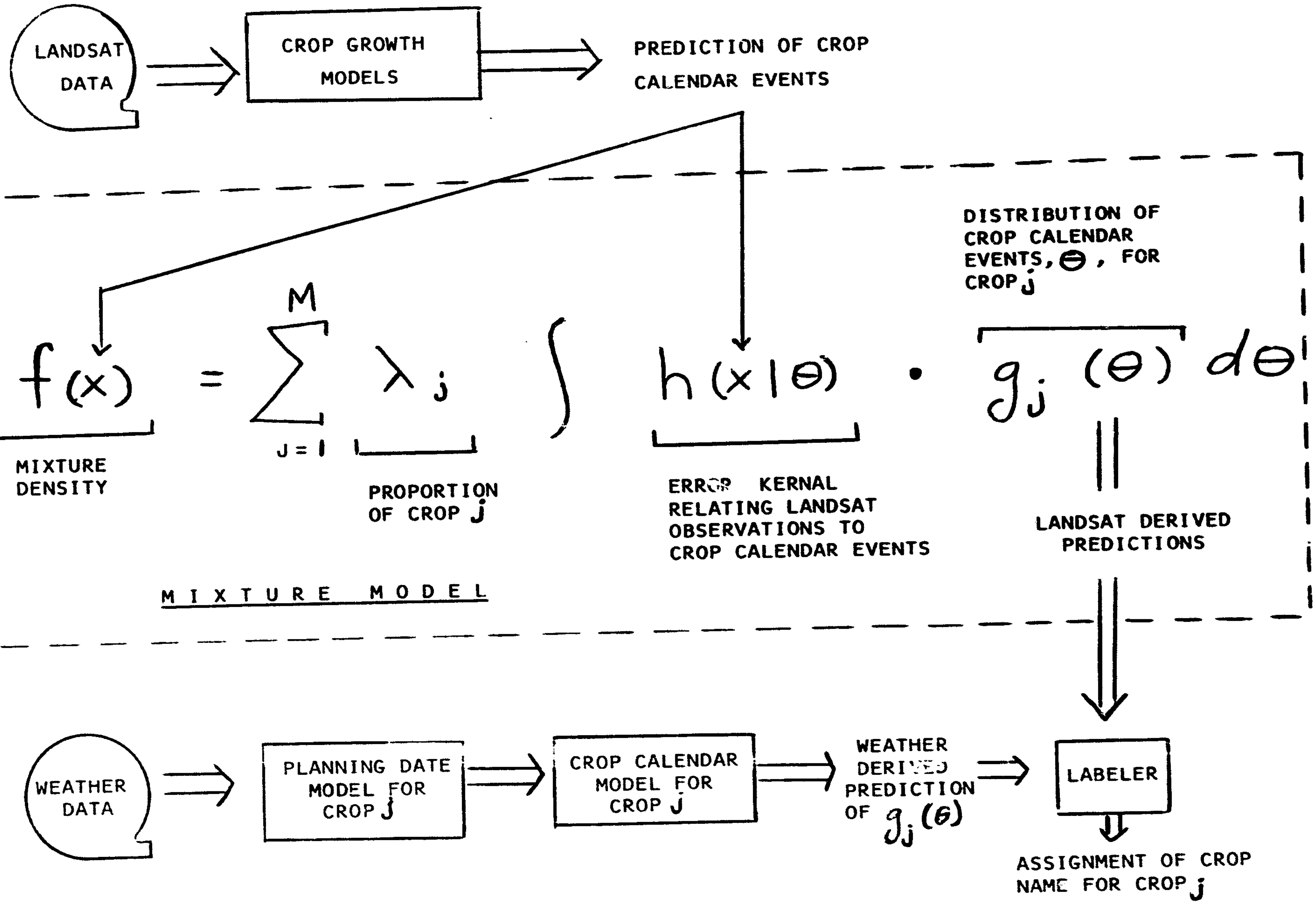
$$\underset{\text{MIXTURE DENSITY}}{f(x)} = \sum_{i}^{M} \underset{\text{CROP PROP.}}{\lambda_i} \cdot \underset{\text{CROP LIKELIHOOD}}{f_i(x)}$$




CLASSIFICATION APPROACH
DIVIDES THE SPECTRAL VALUES
(X) INTO GROUPS

MIXTURE MODEL VS CLASSIFICATION APPROACH

APEP AT-HARVEST DESIGN



## APEP STUDY RESULTS

- O THE FIRST SERIES OF APEP STUDIES WILL NOT ATTEMPT TO BREAK OUT THE COMPONENTS, $h_j(x|\Theta)$ AND $g_j(\Theta)$ OF THE INTEGRAND, BUT RATHER WILL CONSIDER A SIMPLER VERSION OF THIS MIXTURE MODEL, VIZ,

$$f(x) = \sum_{j=1}^{M} \lambda_j f_j(x)$$

WHERE $f_j(x)$ IS THE j<u>th</u> CROP SPECTRAL DISTRIBUTION.

- O ONE SERIES OF STUDIES IS AIMED AT METHODS FOR ESTIMATING "M" WHICH IS THE NUMBER OF CROP/MATERIAL SPECTRAL CLASSES.
  - + IN THIS STUDY A CRITERION KNOWN AS THE AKAIKE INFORMATION CRITERION (AIC) IS MINIMIZED TO ESTIMATE M.
  - + AIC IS DEFINED

    AIC = $-2 \cdot$(LOGLIKELIHOOD FUNCTION) + $2 \cdot$(NUMBER OF FREE PARAMETERS)
  - + THE OBJECTIVE OF THE STUDY WAS TO EVALUATE THE AIC ABILITY TO DETECT THE CORRECT NUMBER OF SPECTRAL CLASSES AS A FUNCTION OF THE PROXIMITY OF THE CLASSES. THE STUDY WAS DONE ON SIMULATED DATA.
  - + WHEN A "REASONABLE" SEPARATION BETWEEN CLASSES EXISTS, AIC COULD CORRECTLY ESTIMATE THE NUMBER OF SPECTRAL CLASSES.

## APEP STUDY RESULTS (CONT.)

O ANOTHER SERIES OF STUDIES HAS BEEN AIMED AT DERIVING THE "X-VARIABLES" RELATED TO GROWTH STAGE EVENTS FROM AN ANALYSIS OF PROFILE MODELS.

- + 14 COMBINATIONS OF PROFILE PARAMETERS HAVE BEEN EVALUATED.

- + TWO COMBINATIONS SHOW PROMISE

  -- TIME OF SECOND GREENNESS INFLECTION -- TIME OF FIRST GREENNESS INFLECTION. ESTIMATE O. GROWING "LENGTH"

  -- TIME OF THE PEAK GREENNESS VALUE

- + OBJECTIVE IS TO DEVELOP VARIABLES THAT PRESERVE CROP SEPARATION AND HAVE PROBABILITY DISTRIBUTIONS THAT CAN BE EASILY MODELED.

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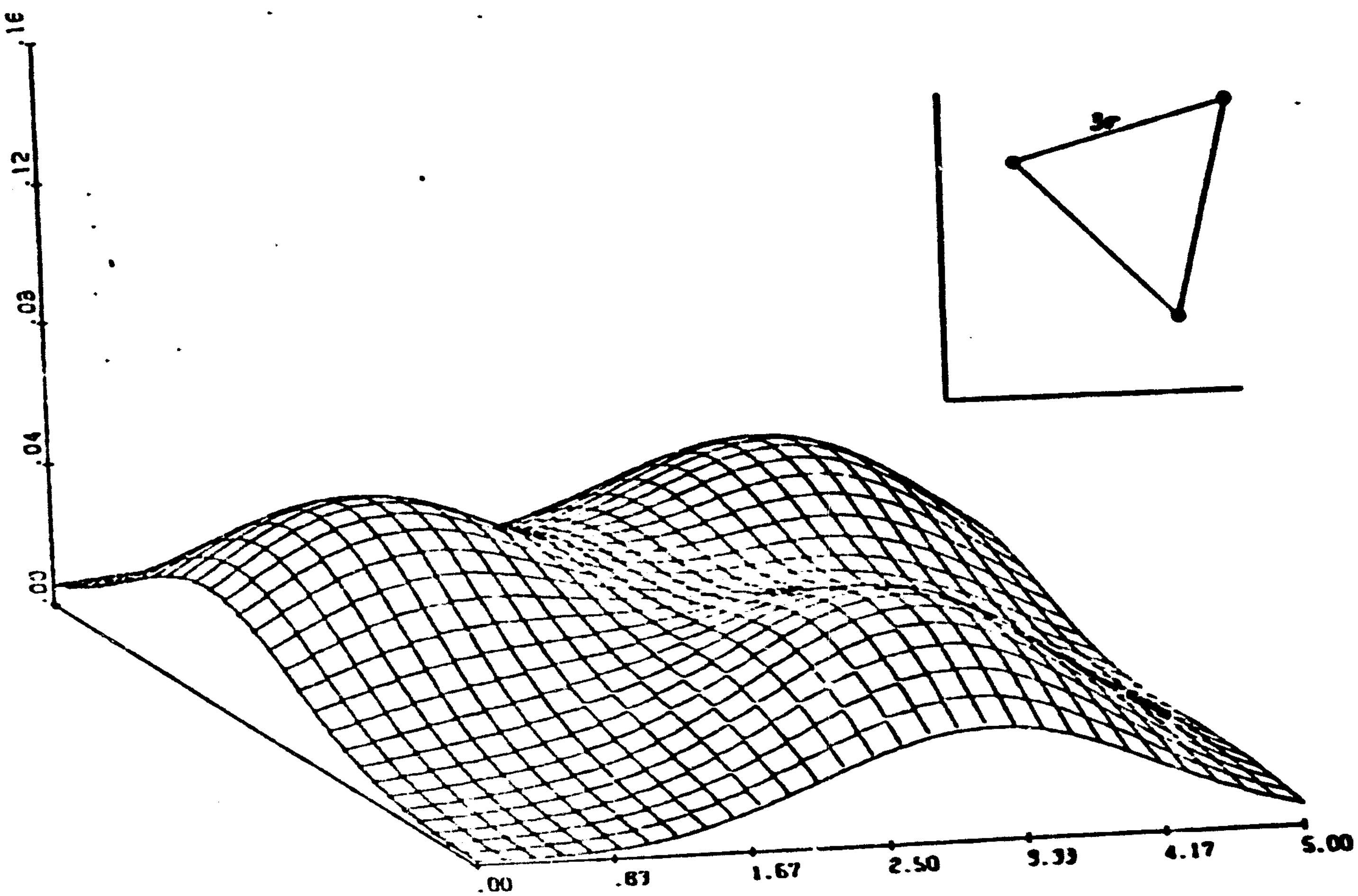



CASE I. MODEL MIXTURE DENSITY.

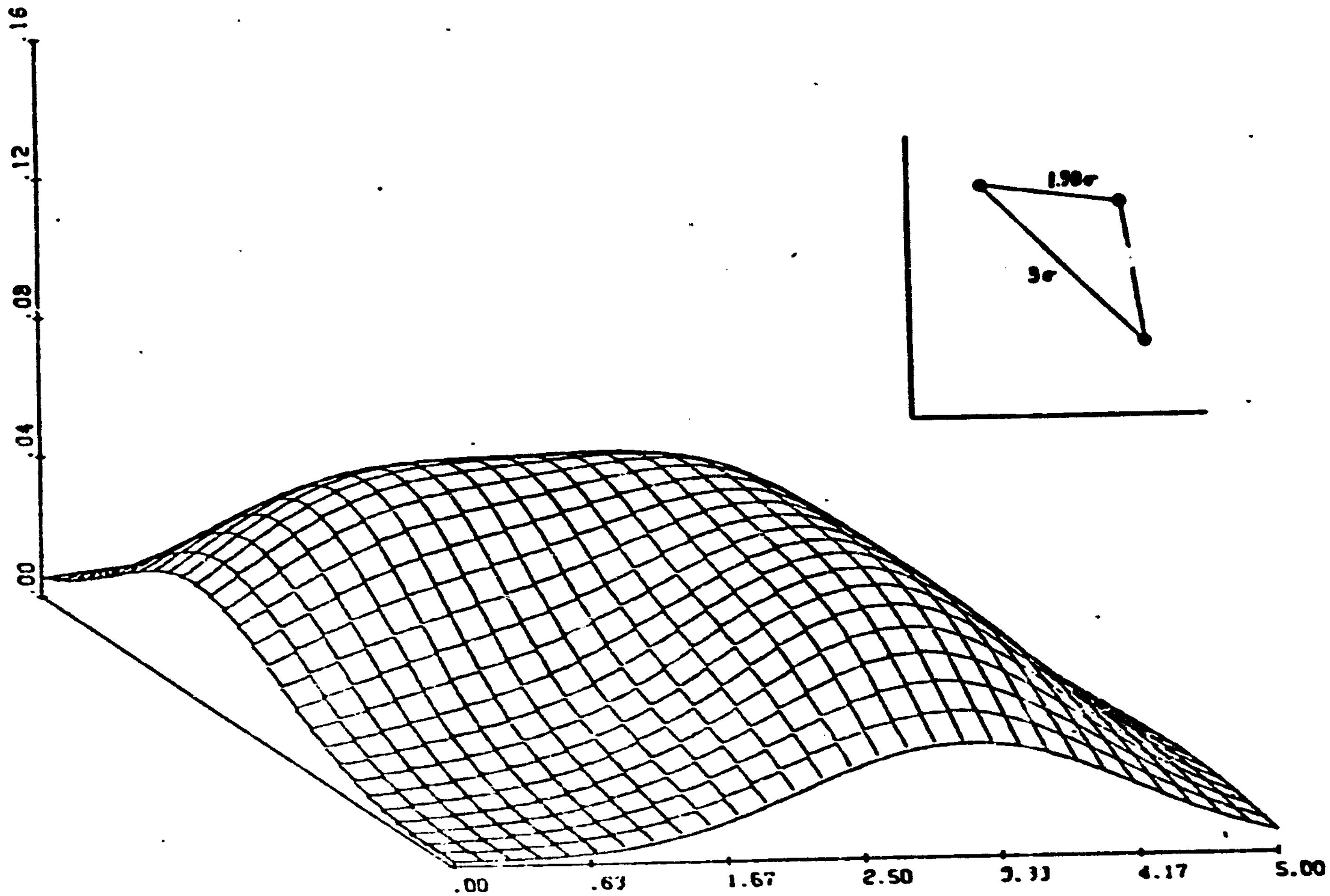
## CASE I

### TRUE MEAN VALUES

| | |
|---|---|
| CLASS 1 | 3.12, 1.00 |
| CLASS 2 | 1.00, 3.12 |
| CLASS 3 | 3.90, 3.90 |

### TABLE OF AIC VALUES (500 POINTS)

| NO. OF CLASSES | AIC VALUES |
|---|---|
| 1 | 3729.1 |
| 2 | 3701.8 |
| 3 | 3642.7 * |
| 4 | 3648.2 |




CASE II. MODEL MIXTURE DENSITY.

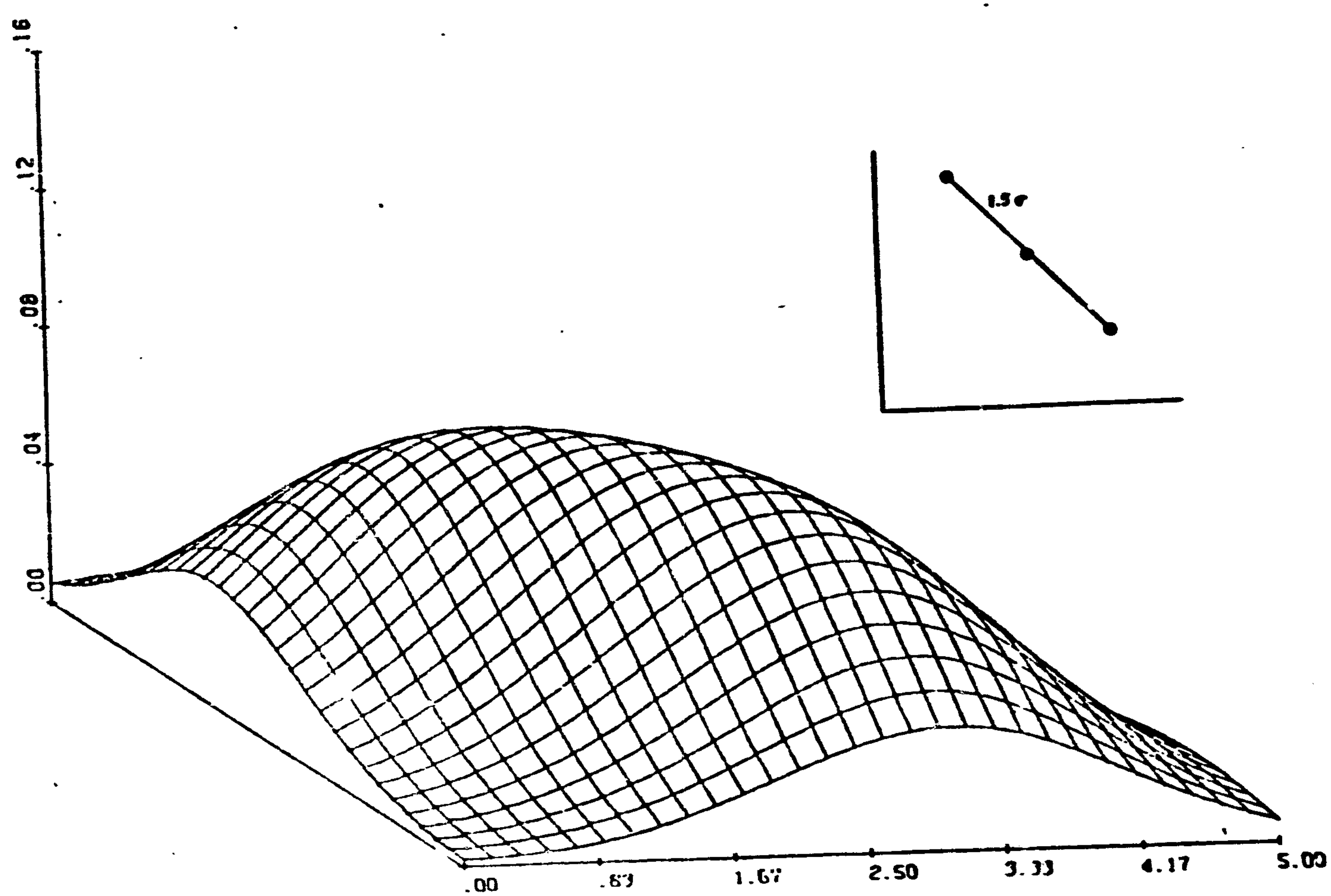
## CASE II

### True Mean Values

| | |
|---|---|
| Class 1 | 3.12, 1.00 |
| Class 2 | 1.00, 3.12 |
| Class 3 | 3.00, 3.00 |

### TABLE OF AIC VALUES (500 POINTS)

| No. of Classes | AIC Values |
|---|---|
| 1 | 3514.4 |
| 2 | 3471.0 |
| 3 | 3467.4 * |
| 4 | 3472.4 |




CASE III. MODEL MIXTURE DENSITY.

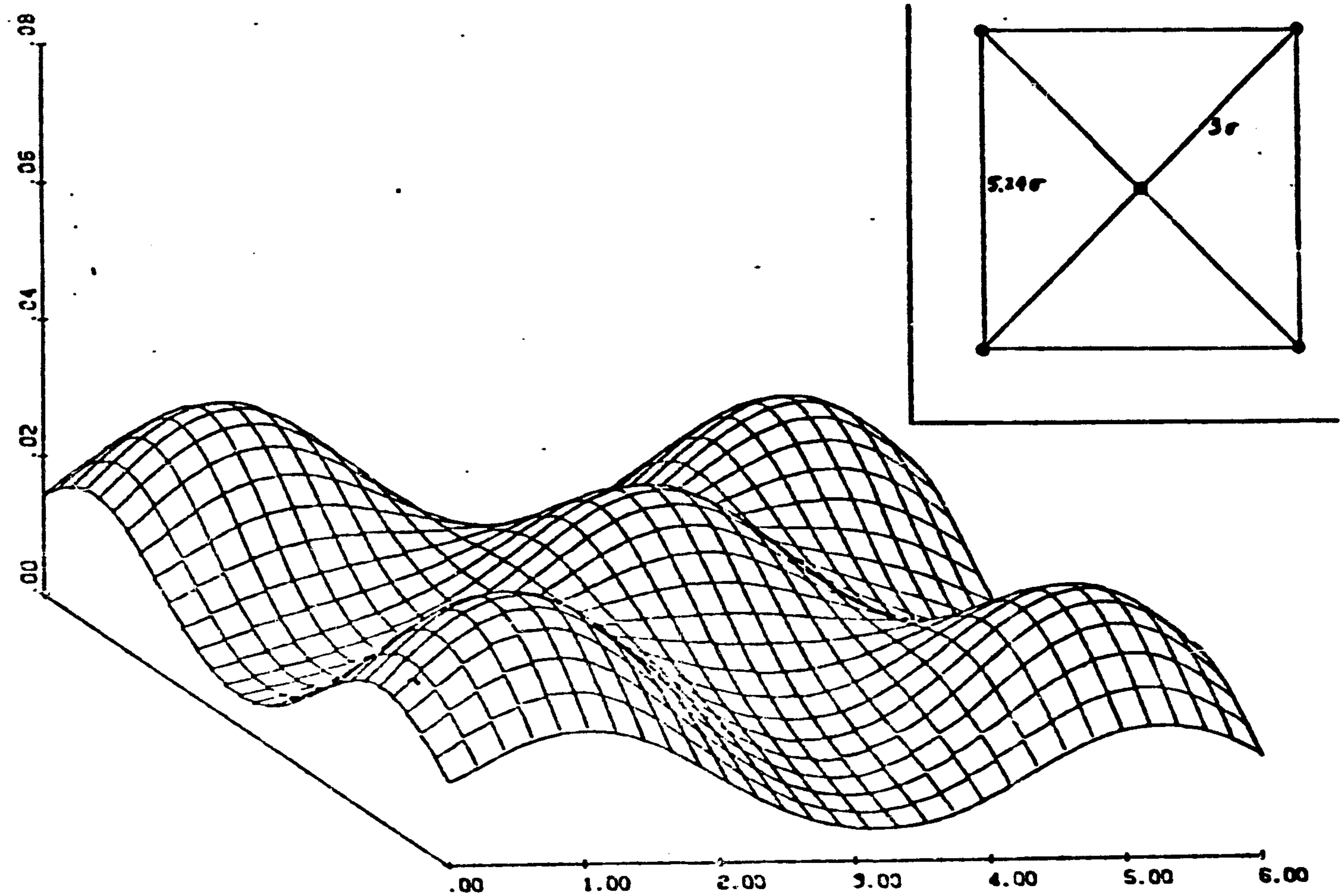
## CASE III

### True Mean Values

| | |
|---|---|
| Class 1 | 3.12, 1.00 |
| Class 2 | 1.00, 3.12 |
| Class 3 | 2.06, 2.06 |

### TABLE OF AIC VALUES (500 POINTS)

| No. of Classes | AIC Values |
|---|---|
| 1 | 3285.8 |
| 2 | 3250.2 * |
| 3 | 3250.8 0 |
| 4 | 3256.4 |




CASE IV. MODEL MIXTURE DENSITY.

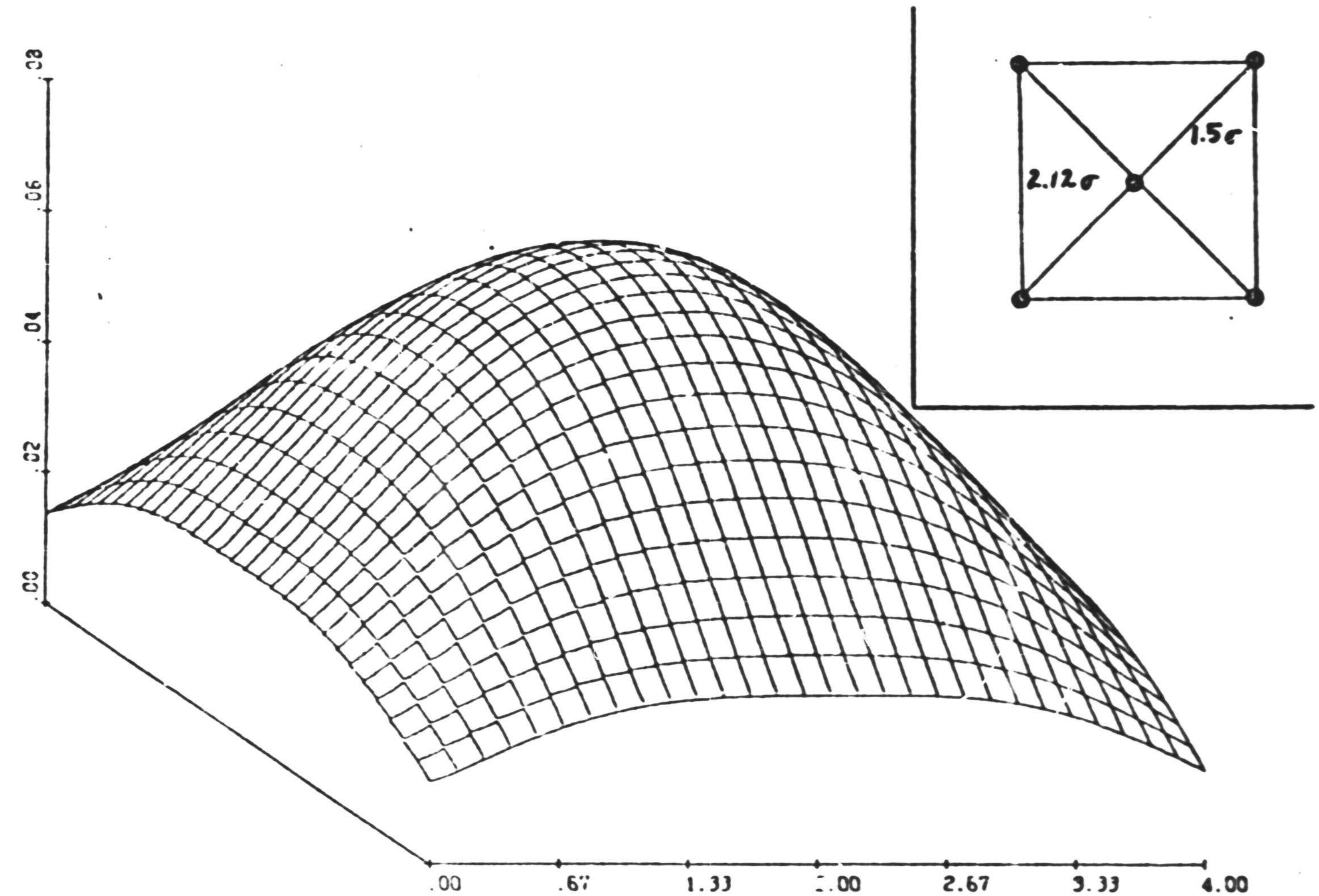
## CASE IV

### TRUE MEAN VALUES

| | |
|---|---|
| CLASS 1 | 1.00, 1.00 |
| CLASS 2 | 5.24, 1.00 |
| CLASS 3 | 5.24, 5.24 |
| CLASS 4 | 1.00, 5.24 |
| CLASS 5 | 3.12, 3.12 |

### TABLE OF AIC VALUES (1000 POINTS)

| NO. OF CLASSES | AIC VALUES |
|---|---|
| 1 | 8702.4 |
| 2 | 8560.6 |
| 3 | 8564.4 |
| 4 | 8411.4 |
| 5 | 8315.4 * |
| 6 | 8321.6 |




CASE V. MODEL MIXTURE DENSITY.

## CASE V

### TRUE MEAN VALUES

| | |
|---|---|
| CLASS 1 | 1.00, 1.00 |
| CLASS 2 | 3.12, 1.00 |
| CLASS 3 | 3.12, 3.12 |
| CLASS 4 | 1.00, 3.12 |
| CLASS 5 | 2.06, 2.06 |

### TABLE OF AIC VALUES (1000 POINTS)

| NO. OF CLASSES | AIC VALUES |
|---|---|
| 1 | 6803.8 |
| 2 | 6795.6 0 |
| 3 | 6801.6 |
| 4 | 6794.2 * |
| 5 | 6796.8 0 |
| 6 | 6802.0 |

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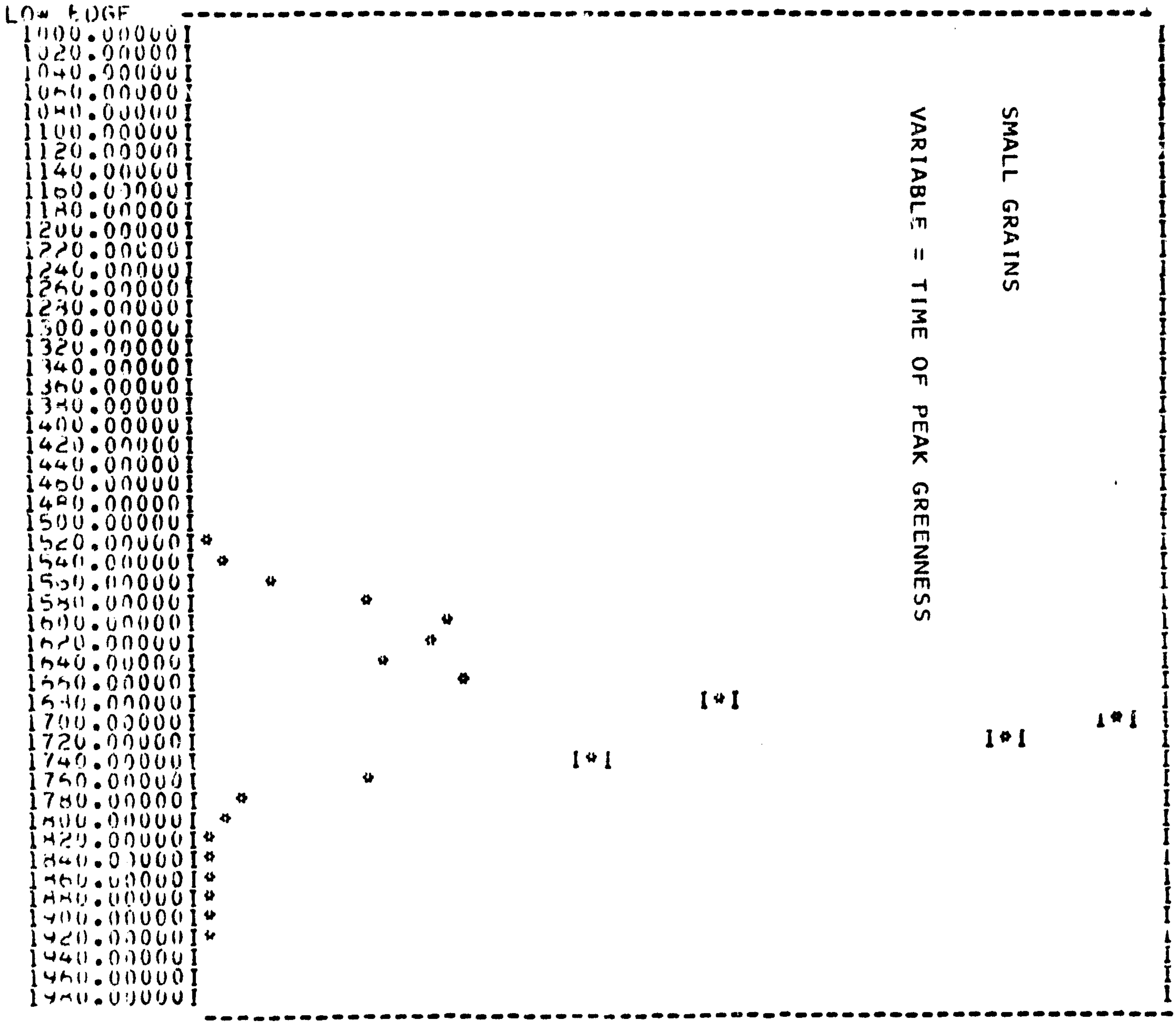
CLASSIFICATION

```
DATE : 10/08/81 TIME :  7:57: 7

GROUND TRUTH FILE=  165377340
CROP = SSG    SG                  1000ATO
                                    Tp
MINIMUM=    1000.00000
MAXIMUM=    2000.00000
NO. BIN=      50
INTERVAL=     20.00000
UNDER MIN      0
OVER MAX       9
NPLOTTED=          5206 MEAN=    0.16979F+04 SIGMA=    0.635136E+02
```



```
DATE : 10/08/81 TIME :  7:50: 7

GROUND TRUTH FILE-  166377340                                          CLASSIFICATION
CROP = SSG     SC                        100XTO
                                          Tp
MINIMUM=     1000.00000
MAXIMUM=     2000.00000
NO. BIN=       50
INTERVAL=      20.00000
UNDER MIN      30
OVER MAX     1568
NPLOTTED=              3456 MEAN=    0.19064E+04 SIGMA=    0.10435E+03

LOW EDGE     ----------------------------------------------------------------
  1000.00000I                                                               I
  1020.00000I                                                               I
  1040.00000I                                                               I
  1060.00000I                                                               I
  1080.00000I                                                               I
  1100.00000I                                                               I
  1120.00000I                                                               I
  1140.00000I                                                               I
  1160.00000I                                                               I
  1180.00000I                                                               I
  1200.00000I                                                               I
  1220.00000I                                                               I
  1240.00000I                                                               I
  1260.00000I                                                               I
  1280.00000I                                                               I
  1300.00000I                                                               I
  1320.00000I                                                               I
  1340.00000I                                                               I
  1360.00000I                                                               I
  1380.00000I                                                               I
  1400.00000I                                                               I
  1420.00000I                                                               I
  1440.00000I                                                               I
  1460.00000I                                                               I
  1480.00000I                                                               I
  1500.00000I                                                               I
  1520.00000I                                                               I
  1540.00000I                                                               I
  1560.00000I                                                               I
  1580.00000I                                                               I
  1600.00000I                                                               I
  1620.00000I                                                               I
  1640.00000I                                                               I
  1660.00000I                                                               I
  1680.00000I                                                               I
  1700.00000I                                                               I
  1720.00000I                                                               I
  1740.00000I                                                               I
  1760.00000I                                                               I
  1780.00000I                                                               I
  1800.00000I                                                               I
  1820.00000I                                                               I
  1840.00000I *                                                             I
  1860.00000I           *                                                   I
  1880.00000I              I*I                                              I
  1900.00000I                                         I*I                   I
  1920.00000I                                                        I*I    I
  1940.00000I                                 I*I                           I
  1960.00000I                I*I                                            I
  1980.00000I           *                                                   I
             ----------------------------------------------------------------
```

SUMMER CROPS

VARIABLE = TIME OF PEAK GREENNESS

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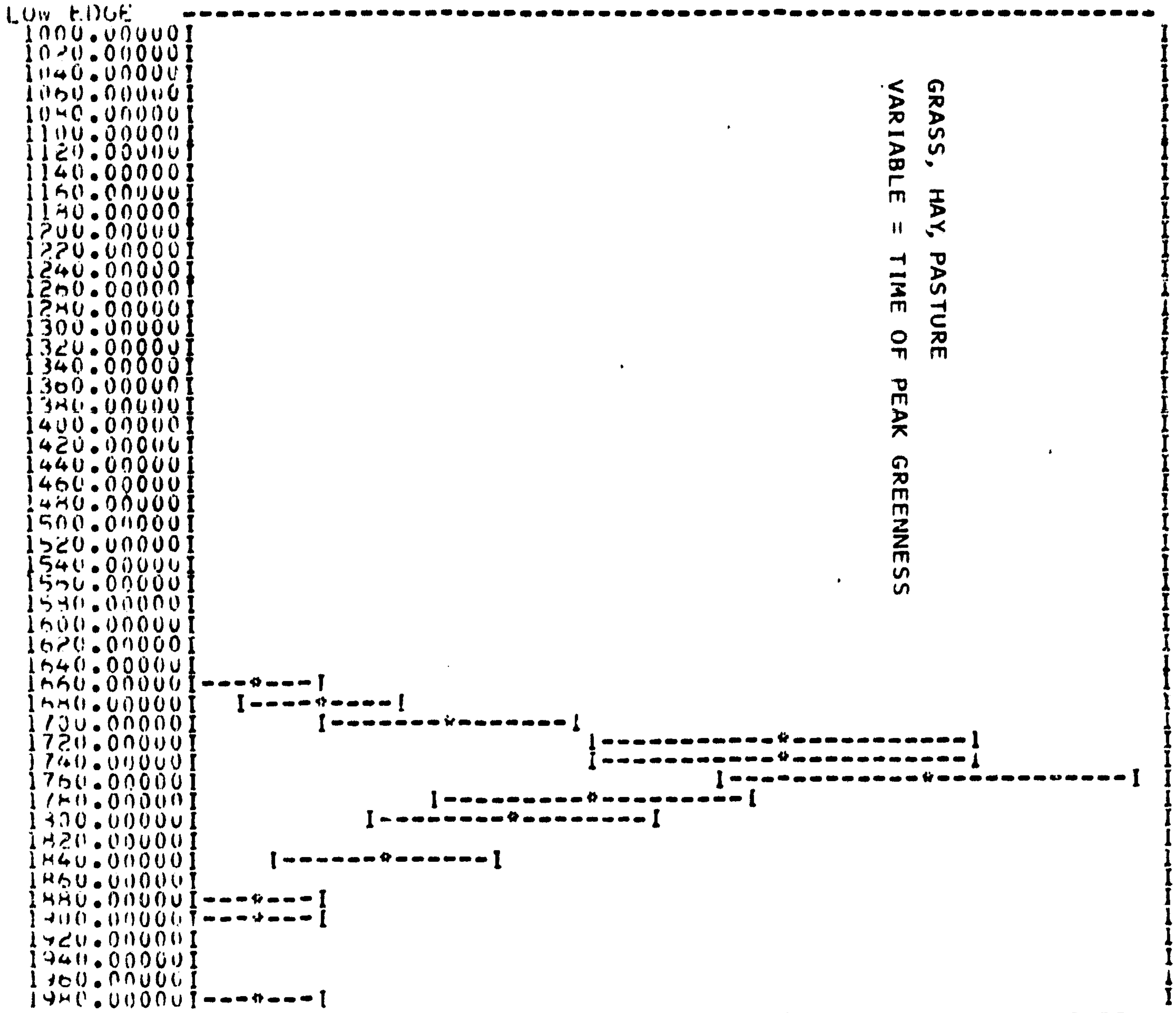
```
DATE : 10/08/81 TIME : 785/812

GROUND TRUTH FILE-  166377340                              CLASSIFICATION
CROP = CONFUS  GHP                 100UATO
                                   Tp
MINIMUM=     1000.00000
MAXIMUM=     2000.00000
NO. BIN=       50
INTERVAL=      20.00000
UNDER MIN       0
OVER MAX        5
NPLOTTED=                53 MEAN=   0.17000E+04 SIGMA=   0.561516E+02
```



DATE : 10/06/81 TIME : 16:22:55

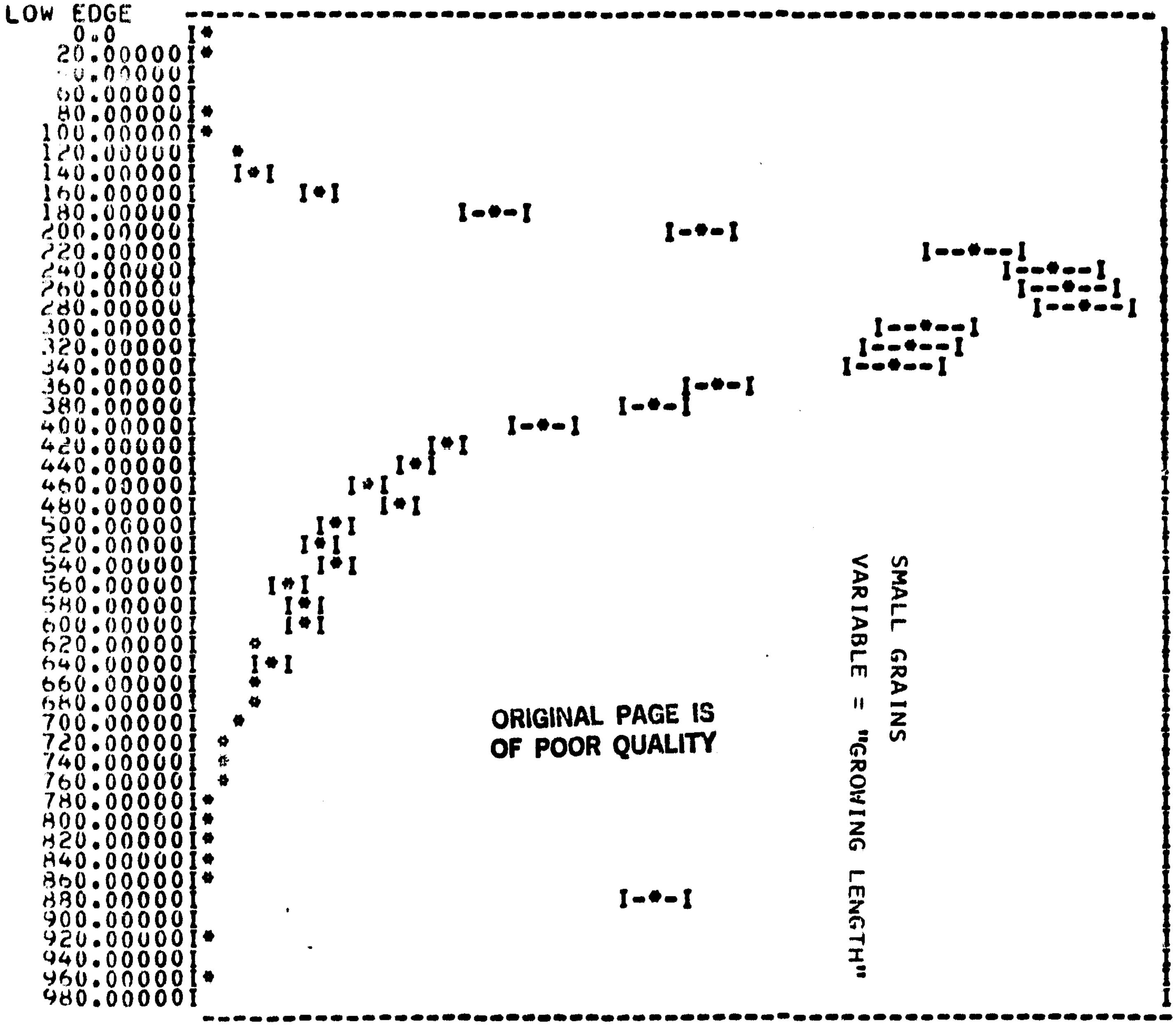
GROUND TRUTH FILE- 139479365 CLASSIFICATIO

CROP = SSG SG

100XCHISORE

$I_2 - T_1$

MINIMUM= 0.0
MAXIMUM= 1000.00000
NO. BIN= 50
INTERVAL= 20.00000
UNDER MIN 34
OVER MAX 123
NPLOTTED= 3275 MEAN= 0.374171E+03 SIGMA= 0.179165E+03



DATE : 10/06/81 TIME : 16:25:18

GROUND TRUTH FILE- 139479365 CLASSIFICATION F
CROP = CONFUS @H? 100UXCHISURE

$T_2 - T_1$

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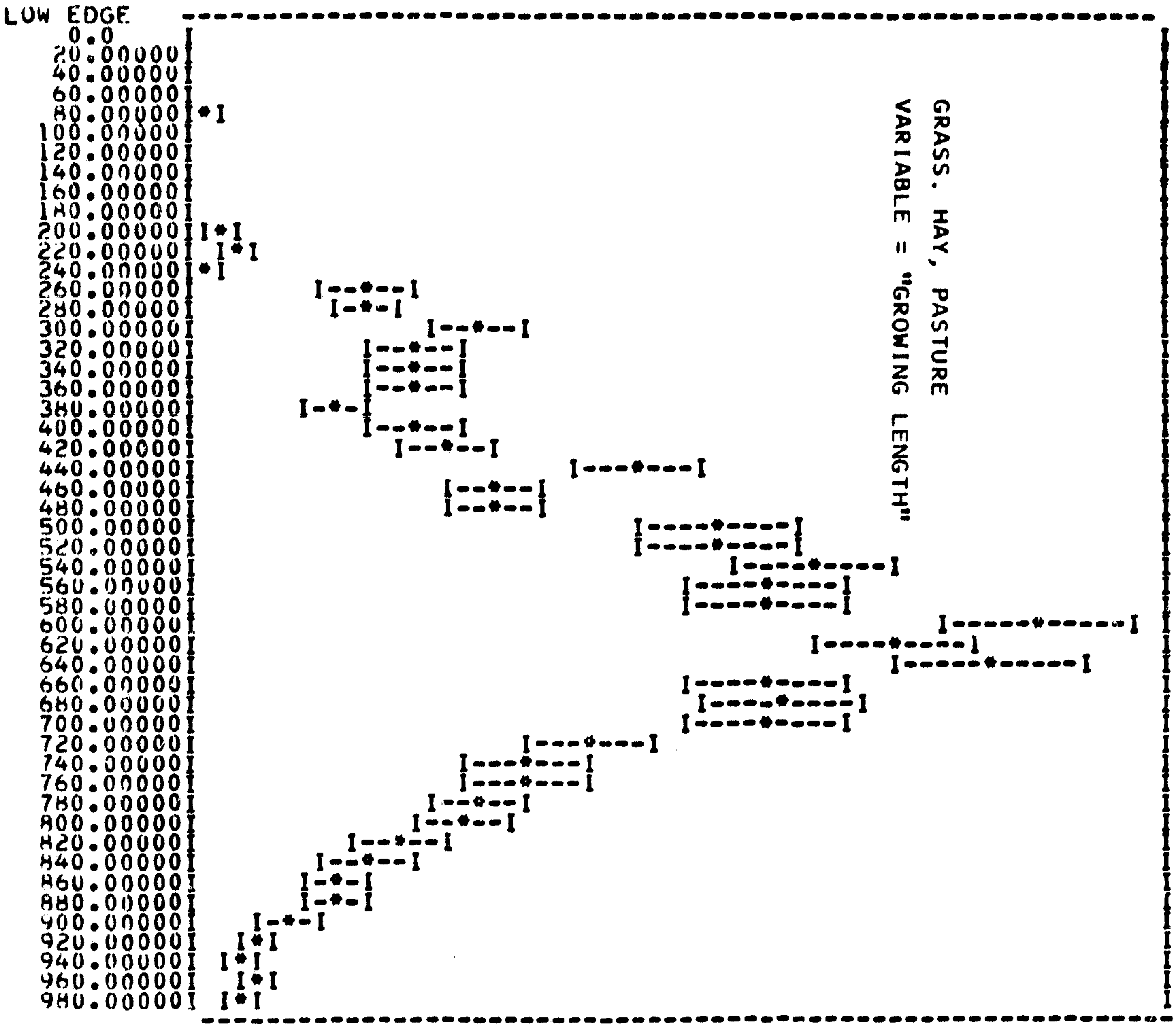
MINIMUM= 0.0
MAXIMUM= 1000.00000
NO. BIN= 50
INTERVAL= 20.00000
UNDER MIN 0
OVER MAX 49
NPLOTTED= 1032 MEAN= 0.596802E+03 SIGMA= 0.163362E+03

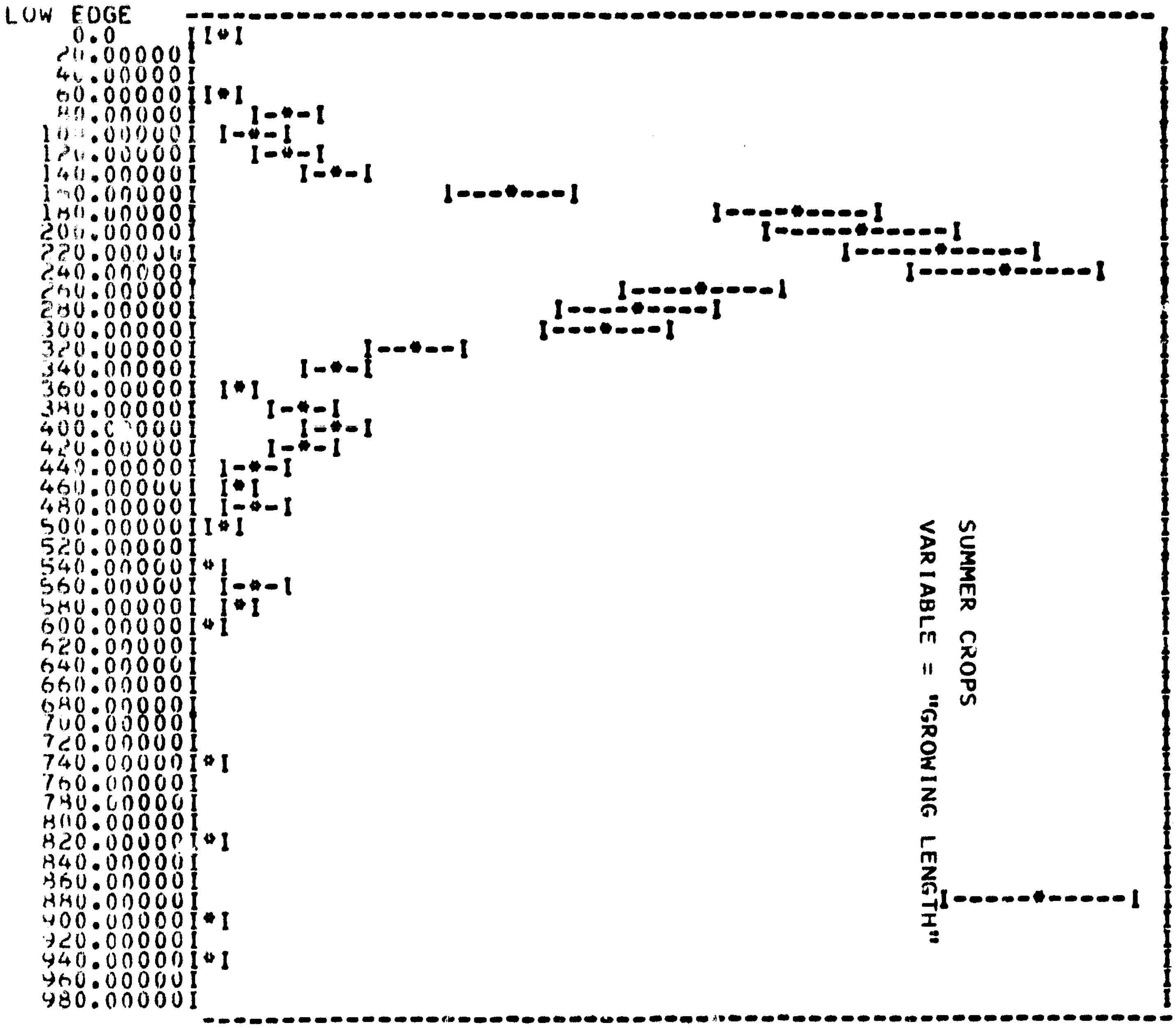


DATE : 10/06/81 TIME : 16:31:33

GROUND TRUTH FILE- 139479365      CLASSIFICATION F
CROP = SSG   SC    1000XCHISQRE

$T_2 - T_1$

MINIMUM= 0.0
MAXIMUM= 1000.00000
NO. BIN= 50
INTERVAL= 20.00000
UNDER MIN 6
OVER MAX 19
NPLOTTED= 524 MEAN= 0.354504E+03 SIGMA= 0.236074E+03



## AG-ECONOMETRIC MODEL STUDIES

- THE EARLY SEASON APPROACH WILL USE AG-ECONOMETRIC MODELS BASED ON ANCILLARY AND PREVIOUS YEAR LANDSAT TO DEVELOP A "PRIOR" ESTIMATE OF ACREAGE PLANTED TO A GIVEN CROP.

- THIS PRIOR ESTIMATE WILL BE COMBINED WITH AN ESTIMATE DERIVED FOR CURRENT YEAR LANDSAT OBSERVATIONS AND, PERHAPS, PRIOR YEAR SEGMENT ESTIMATES.

  + ESTIMATORS SIMILAR TO APEP MIXTURE MODEL ARE BEING PROPOSED THAT USE CURRENT YEAR EARLY SEASON LANDSAT OBSERVATIONS.

  + PREVIOUS RESEARCH SUGGESTS THAT MULTIPLE YEAR MODELS BASED UPON ROTATION DESIGNS AND WEIGHTED AGGREGATION APPROACHES COULD BE USED.

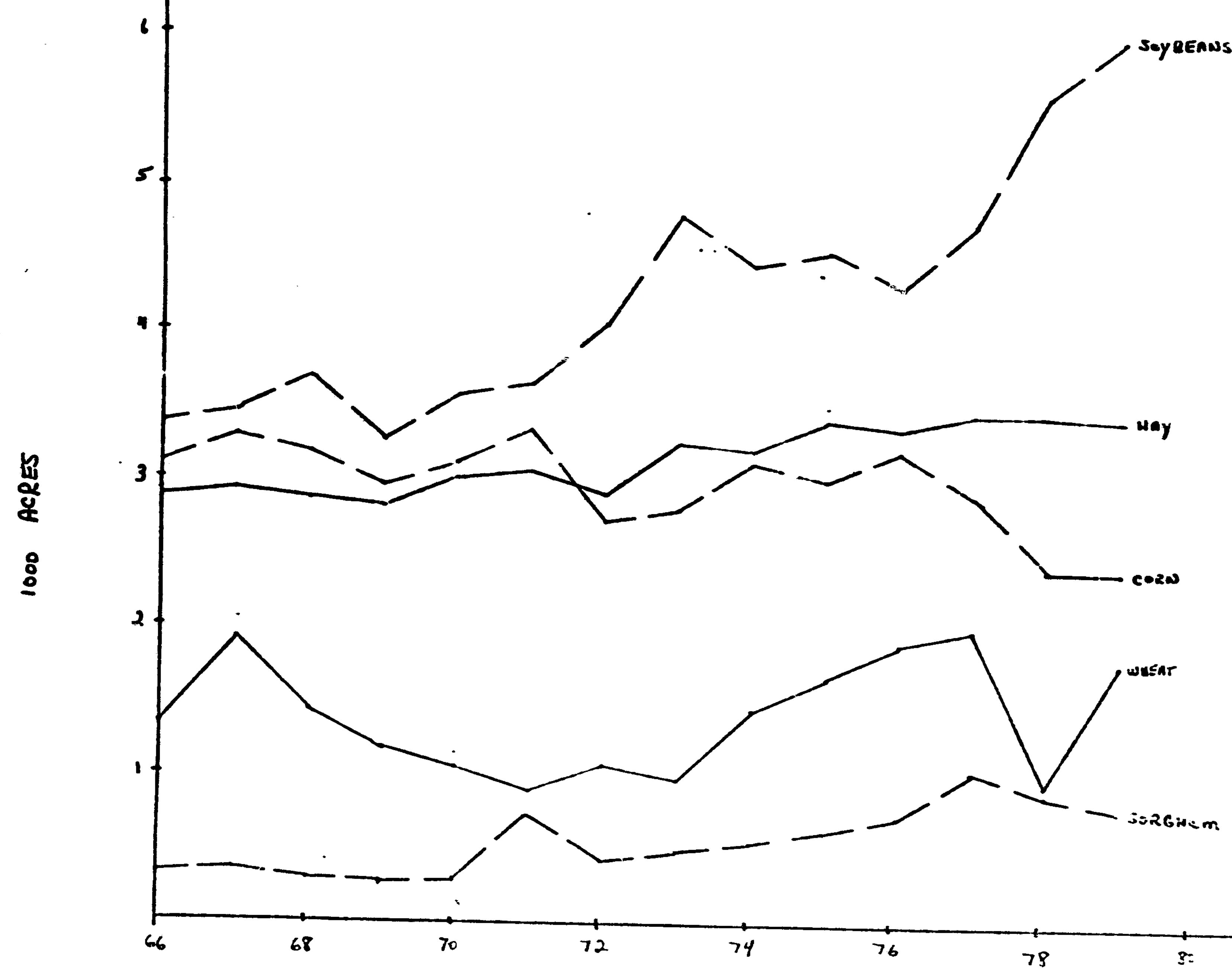
- AN EXTENSION OF AN AG-ECONOMETRIC MODEL DEVELOPED BY DONALD MITCHELL OF THE AGRICULTURAL ECONOMICS DEPARTMENT OF MICHIGAN STATE UNIVERSITY HAS BEEN STUDIED FOR THE CROPS CORN, SOYBEANS, WHEAT, AND SORGHUM IN MISSOURI.

  + MISSOURI WAS SELECTED FOR A STUDY SITE SINCE IT HAS REASONABLY LARGE YEAR-TO-YEAR CHANGES IN CROP ACREAGES.

- THE MODEL IS BASED ON A LINEAR COMBINATION OF A NUMBER OF SUBMODELS AND ESTIMATES OF CURRENT YEAR PLANTED ACREAGES.

  + THE SUBMODELS ARE USED TO DEVELOP VARIABLES WHICH REFLECT PRICE AND GOVERNMENT POLICY CONSIDERATIONS.

MISSOURI CROP ACREAGE



## AG-ECONOMETRIC MODEL STUDIES (CONT.)

O MODEL FORM IS:

$$AP_i(t) = a_0 + a_1\ EXREV_i(t) + \sum_j a_{zj} EXREV_j(t) + a_3 GP1_i(t) + a_4 GP2_i(t) + APSC(t) + APSG(t) + ERROR(t)$$

WHERE

$AP_i(t)$ = ACREAGE PLANTED TO CROP $i$ IN YEAR $t$.

$EXREV_i(t)$ = EXPECTED REVENUE PER ACREAGE FOR CROP $i$ IN YEAR $t$.

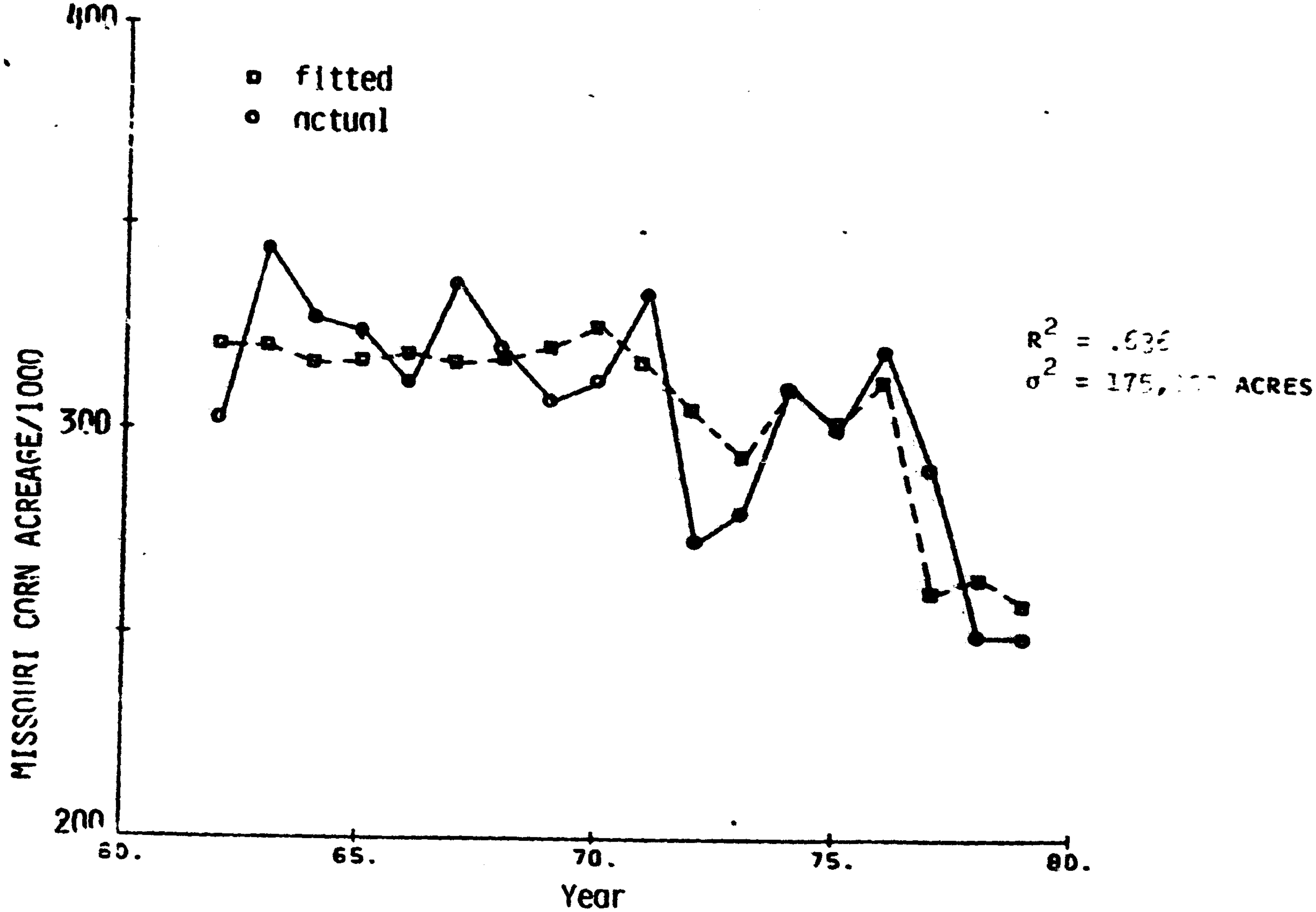
$EXREV_j(t)$ = SAME AS ABOVE EXCEPT FOR COMPETITIVE CROP $j$.

$GP1_i(t)$ = GOVERNMENT POLICY VARIABLE WHICH <u>ENCOURAGES</u> PLANTING OF CROP $i$ (BASED ON DEFICIENCY PAYMENTS AND LOAN RATES).

$GP2_i(t)$ = GOVERNMENT POLICY VARIABLE WHICH <u>DISCOURAGES</u> PLANTING OF CROP $i$ (BASED ON DIVERSION PAYMENTS, DEFICIENCY PAYMENTS, RECOMMENDED VOLUNTARY DIVERSION PERCENTAGES)

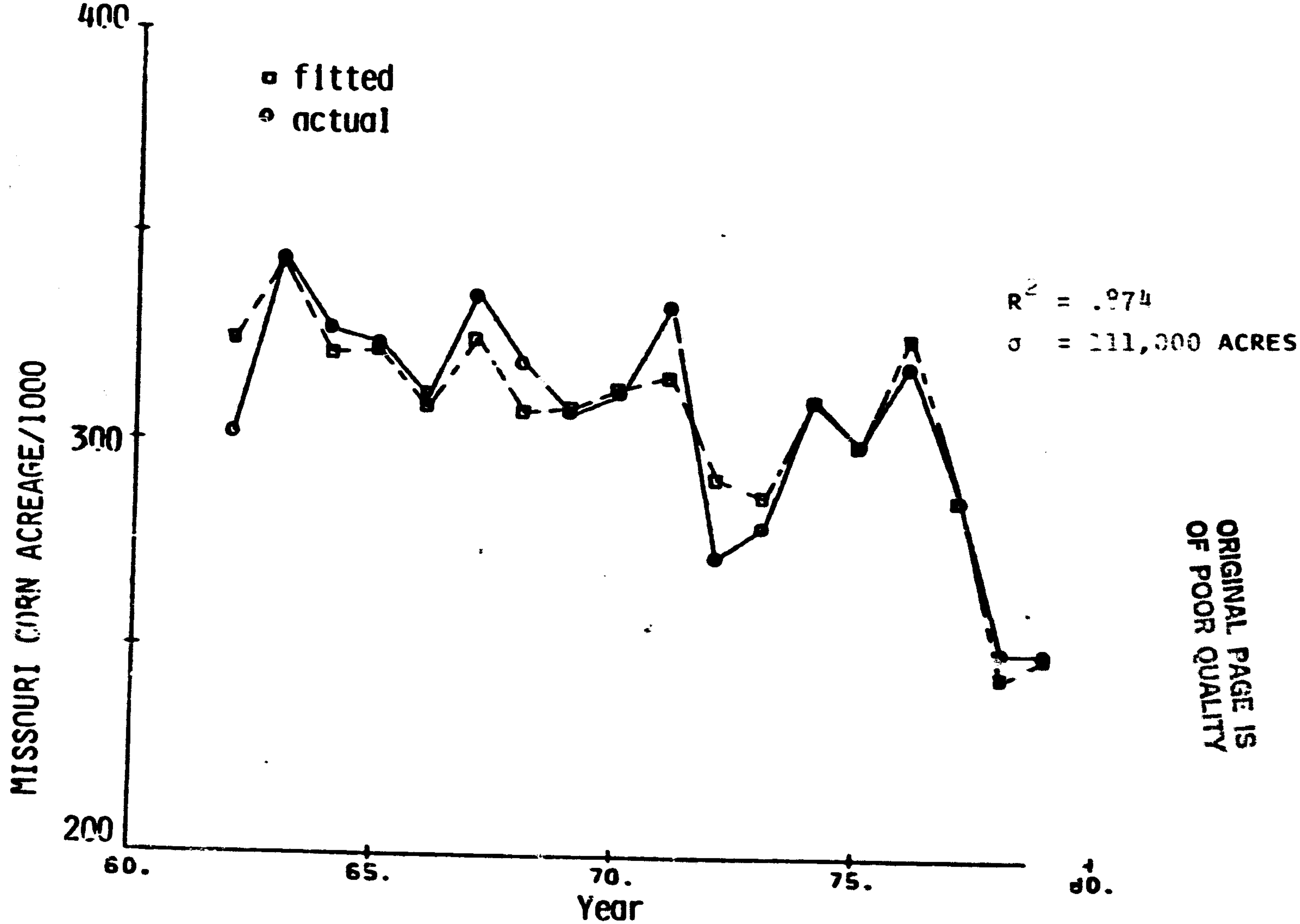
$APSC(t)$ = PLANTED ACREAGE OF SUMMER CROPS IN YEAR $t$.

$APSG(t)$ = PLANTED ACREAGE OF SMALL GRAINS IN YEAR $t$.

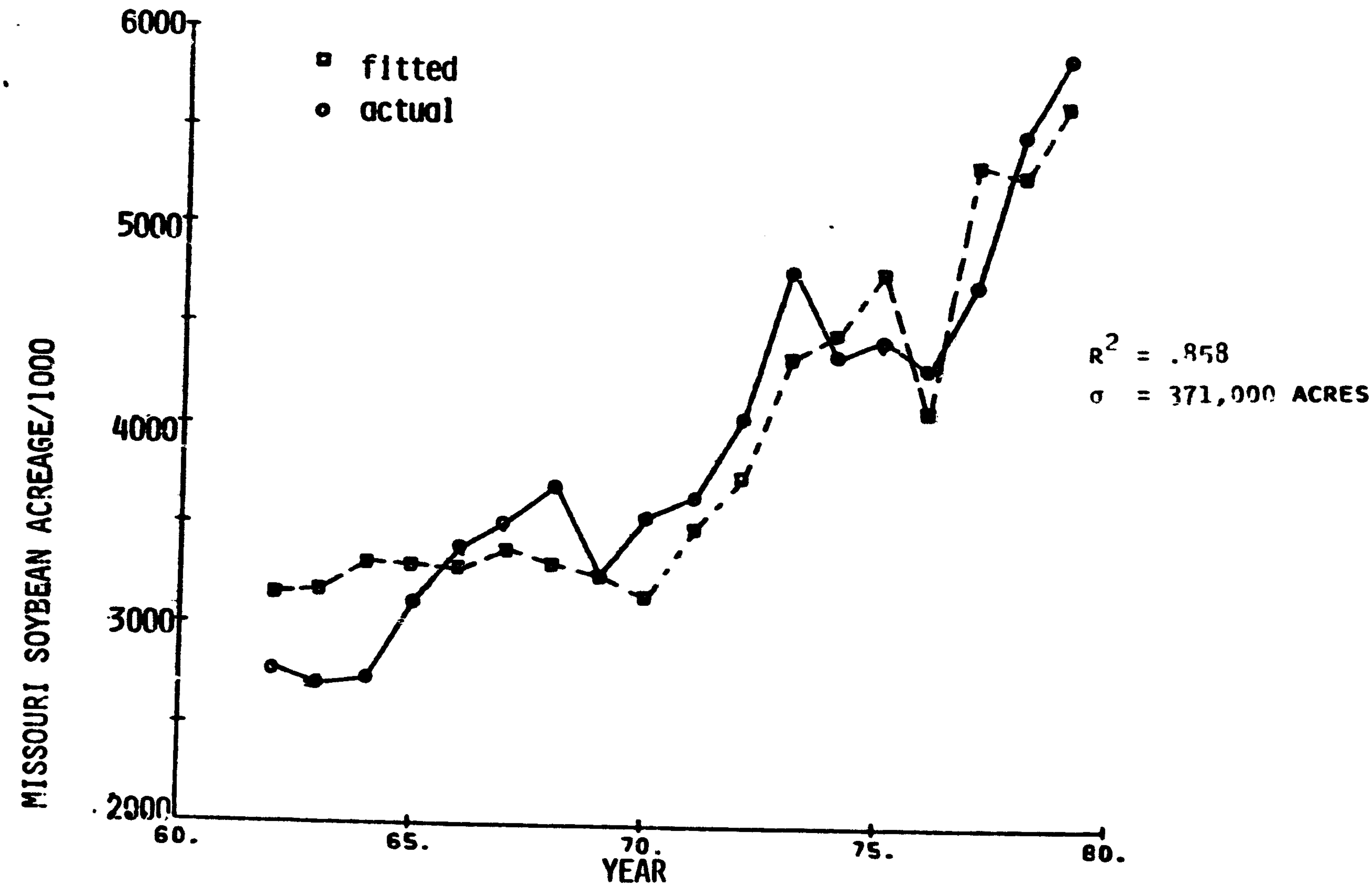



FITTED VS. ACTUAL MISSOURI CORN ACREAGES

Ind. Variables: C, CNREV, SBREV

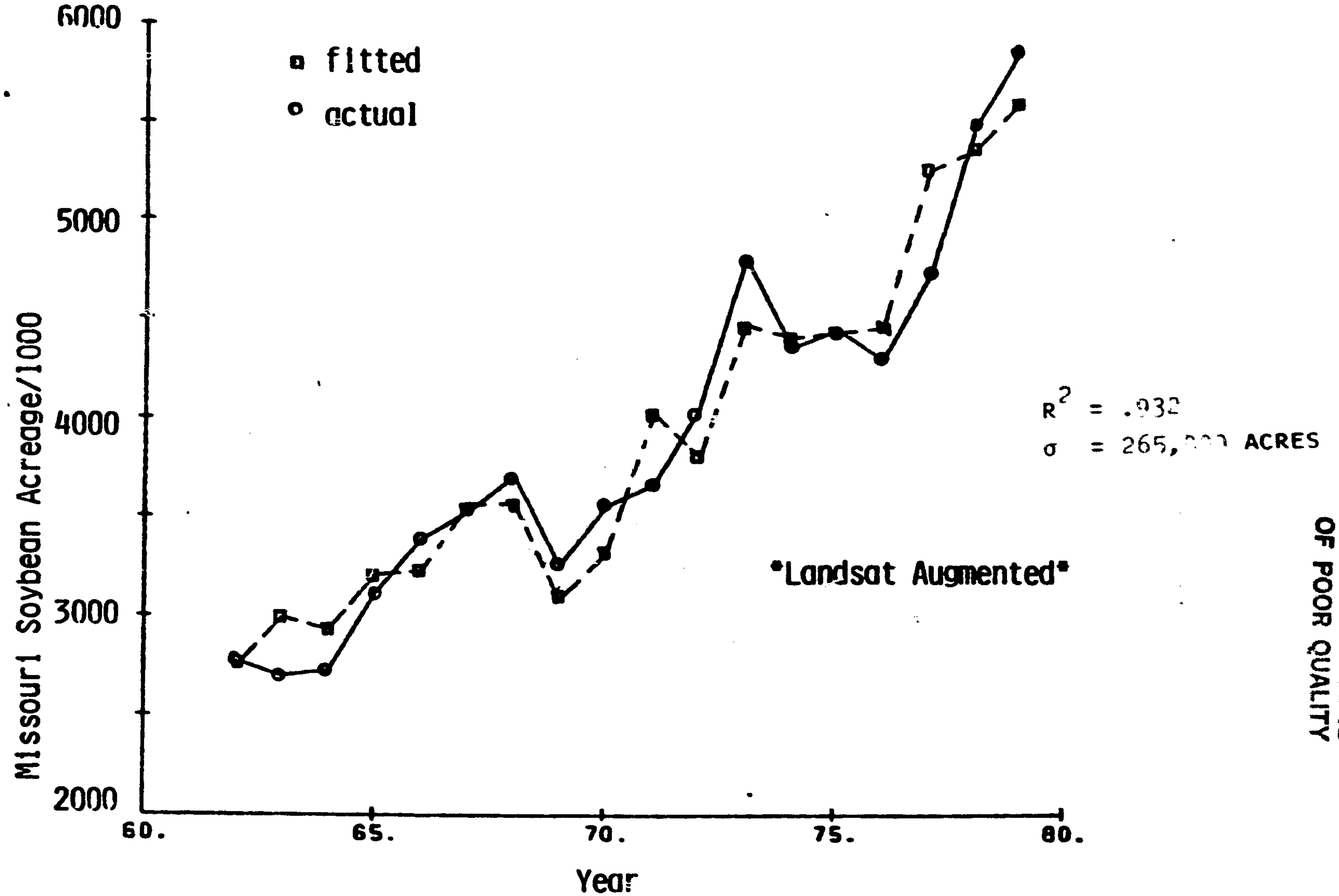



FITTED VS. ACTUAL MISSOURI CORN ACREAGES
Ind. Variables: C, CNREV, SBREV, CNGP1, CNGP2



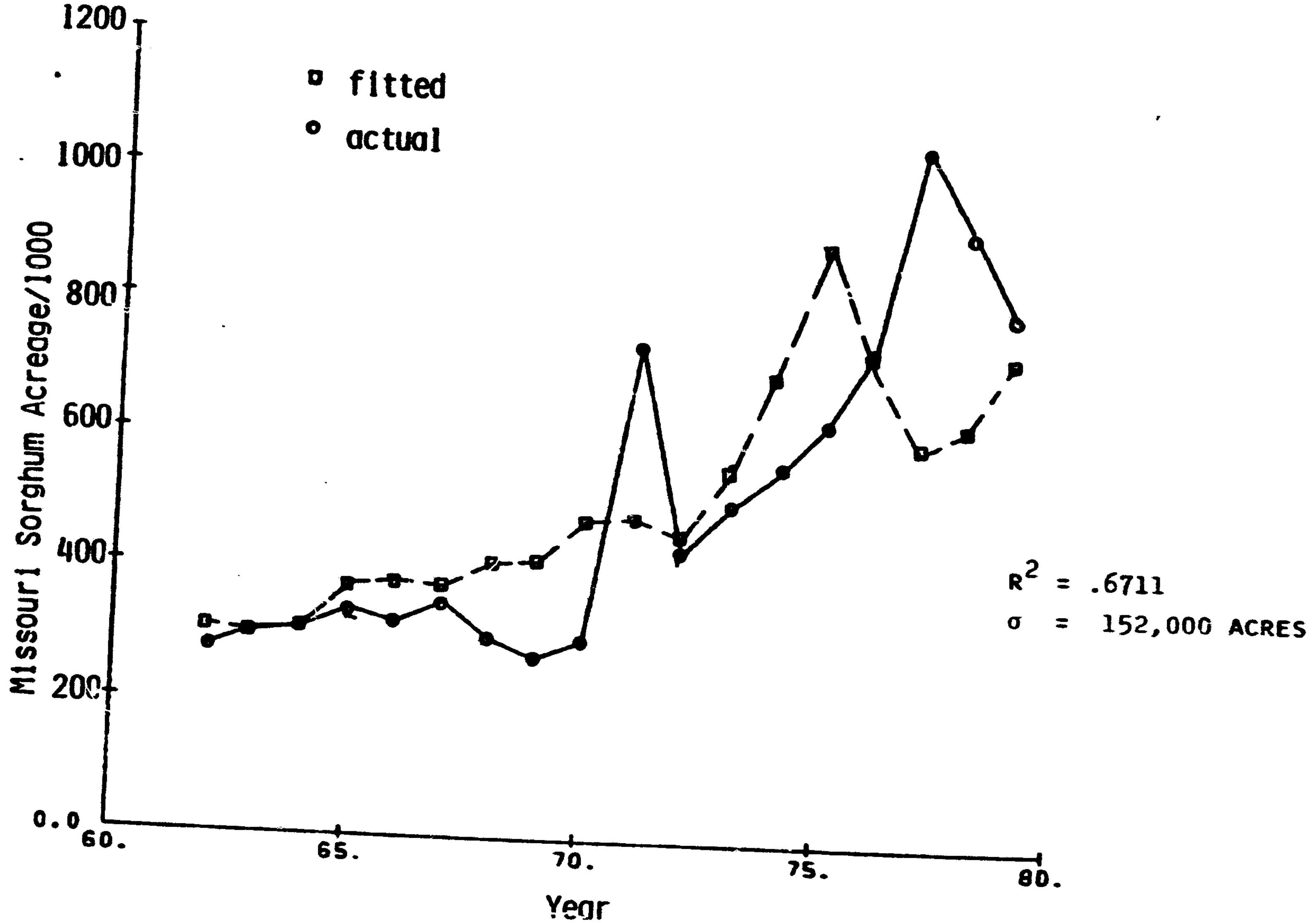

FITTED VS. ACTUAL MISSOURI SOYBEAN ACREAGE

Ind. Variables: C, SBREV, CNREV



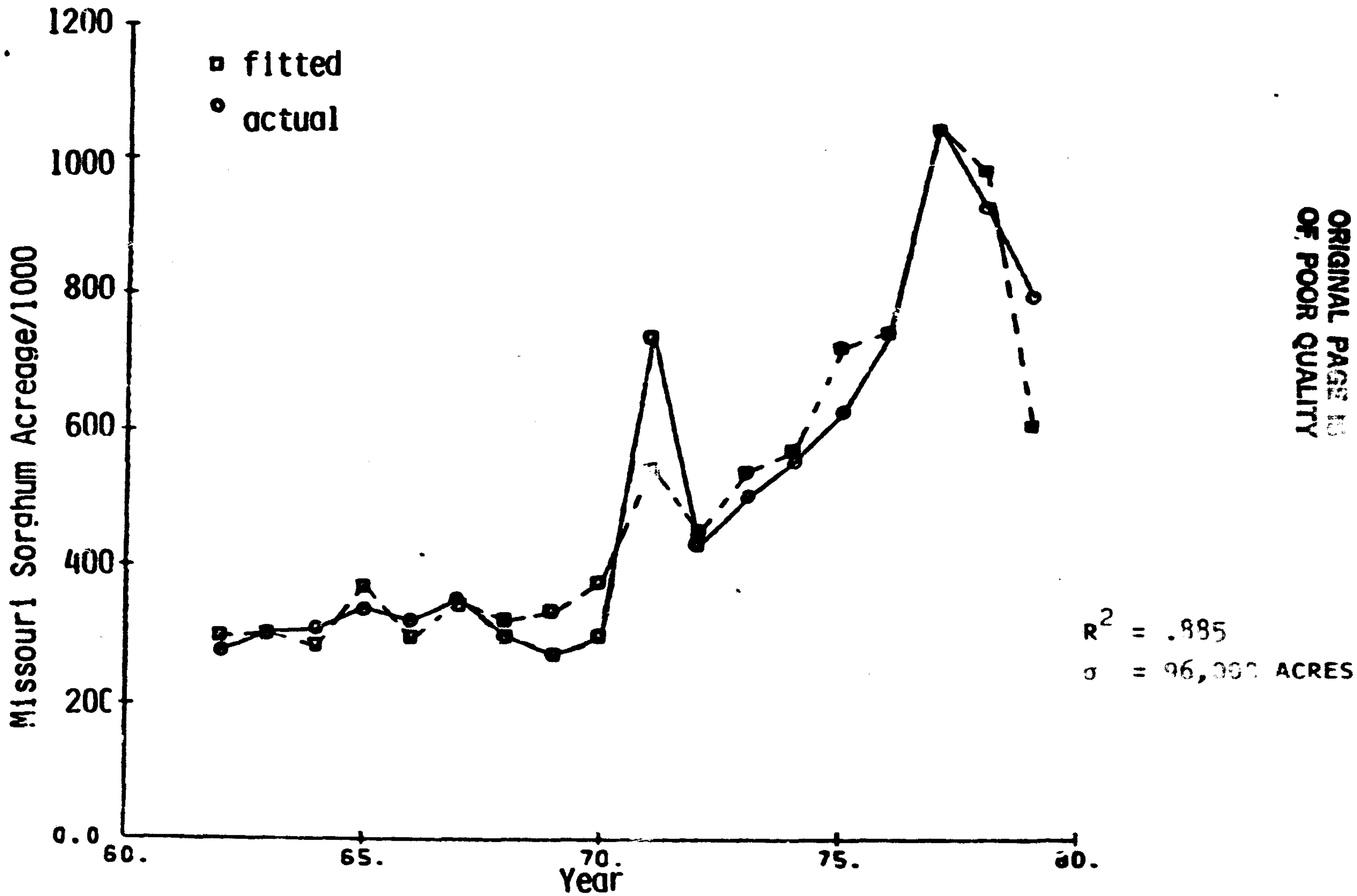

FITTED VS. ACTUAL MISSOURI SOYBEAN ACREAGE

Ind. Variables: C, SBREV, CNREV, APSC



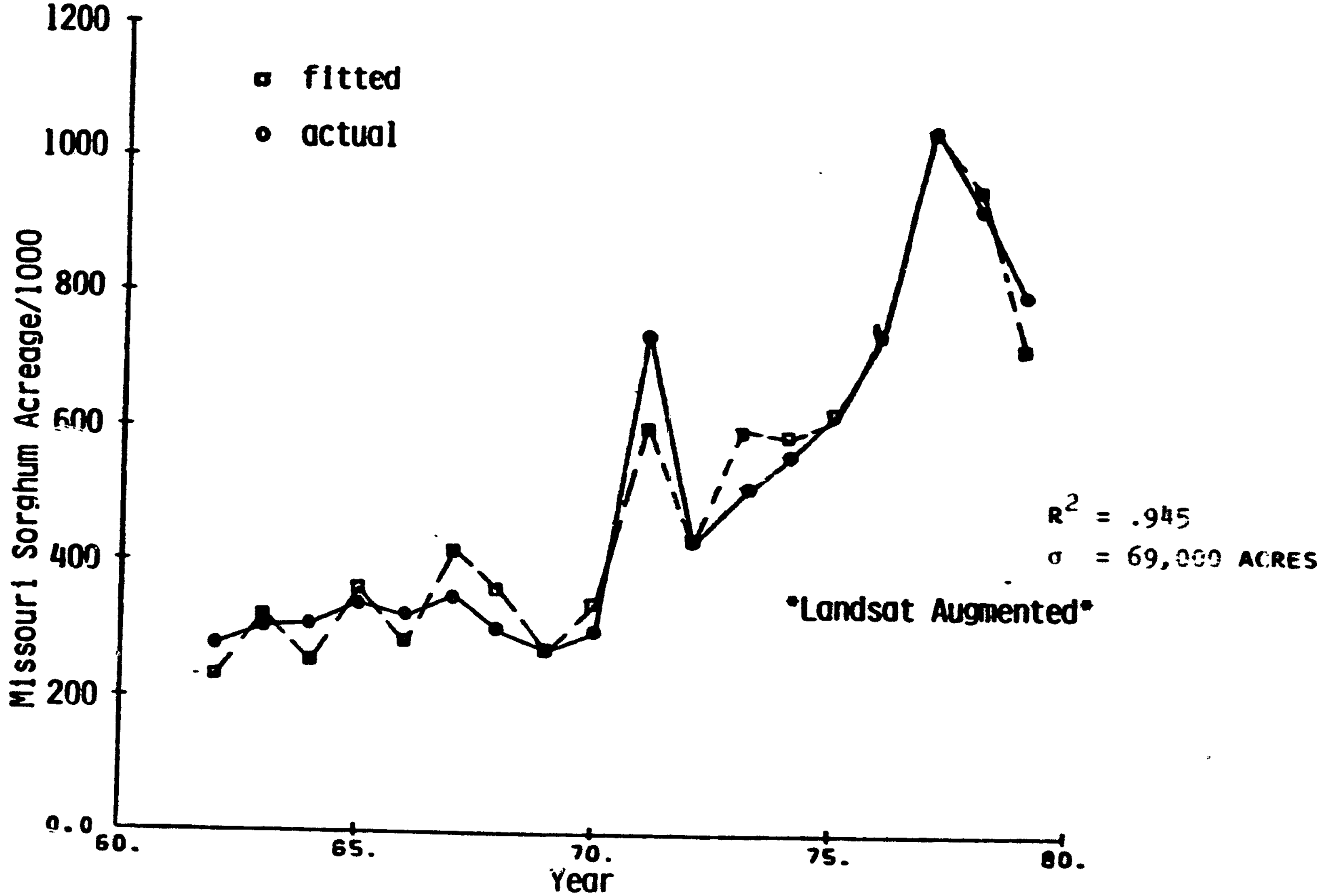

FITTED VS. ACTUAL MISSOURI SORGHUM ACREAGE

Ind. Variables: C, SHREV, WTREV




FITTED VS. ACTUAL MISSOURI SORGHUM ACREAGES

Ind. Variables: C, SHREV, WTREV, SHGP1, SHGP2




FITTED VS. ACTUAL MISSOURI SORGHUM ACREAGE

Ind. Variable: C, SHREV, WTREV, SHGP1, SHGP2, APSC

## OUTLOOK FOR THE NEXT 6 MONTHS



- O IN THE SECOND QUARTER OF FY82 WE EXPECT TO HAVE A PRELIMINARY VERSION OF APEP, CALLED PROCEDURE 1A, EVALUATED.
  - \+ WILL DEMONSTRATE THE FEASIBILITY OF THE "MIXTURE MODEL" APPROACH
  - \+ MAY STILL REQUIRE A MANUAL DISTRIBUTION LABELING APPROACH.
  - \+ INTENT IS TO ESTIMATE SMALL GRAINS AS A GROUP WITHOUT SPECTRALLY SEPARATING ITS COMPONENTS (WHEAT, BARLEY, OATS, RYE, ETC.)
- O AN EARLY SEASON APPROACH WILL HAVE BEEN DEFINED.
  - \+ METHODS FOR USING EARLY SEASON AND MULTIPLE YEAR LANDSAT DATA DEVELOPED.
  - \+ HOW THE ANCILLARY DATA (WEATHER, ECONOMIC, AG) IS TO BE USED WILL BE DEFINED.
  - \+ ESTIMATORS WHICH COMBINE THE BENEFITS OF THESE TWO DATA SOURCES WILL BE PROPOSED.
- O AN EVALUATION OF A DYNAMIC STRATIFICATION APPROACH SHOULD BE COMPLETED EARLY NEXT YEAR.
- O AN EVALUATION OF AN EARLY SEASON VERSION OF THE CORN SOYBEANS CLASSIFICATION APPROACH SHOULD BE COMPLETED. STUDIES ARE UNDERWAY IN WHICH ONLY TWO EARLY ACQUISITIONS ARE BEING STUDIED TO SEPARATE CORN FROM SOYBEANS.
- O AN ERROR MODEL WILL BE FORMULATED TO STUDY THE EFFECTS OF MIXED PIXELS AND OTHER FACTORS ON PROPORTION ESTIMATION.